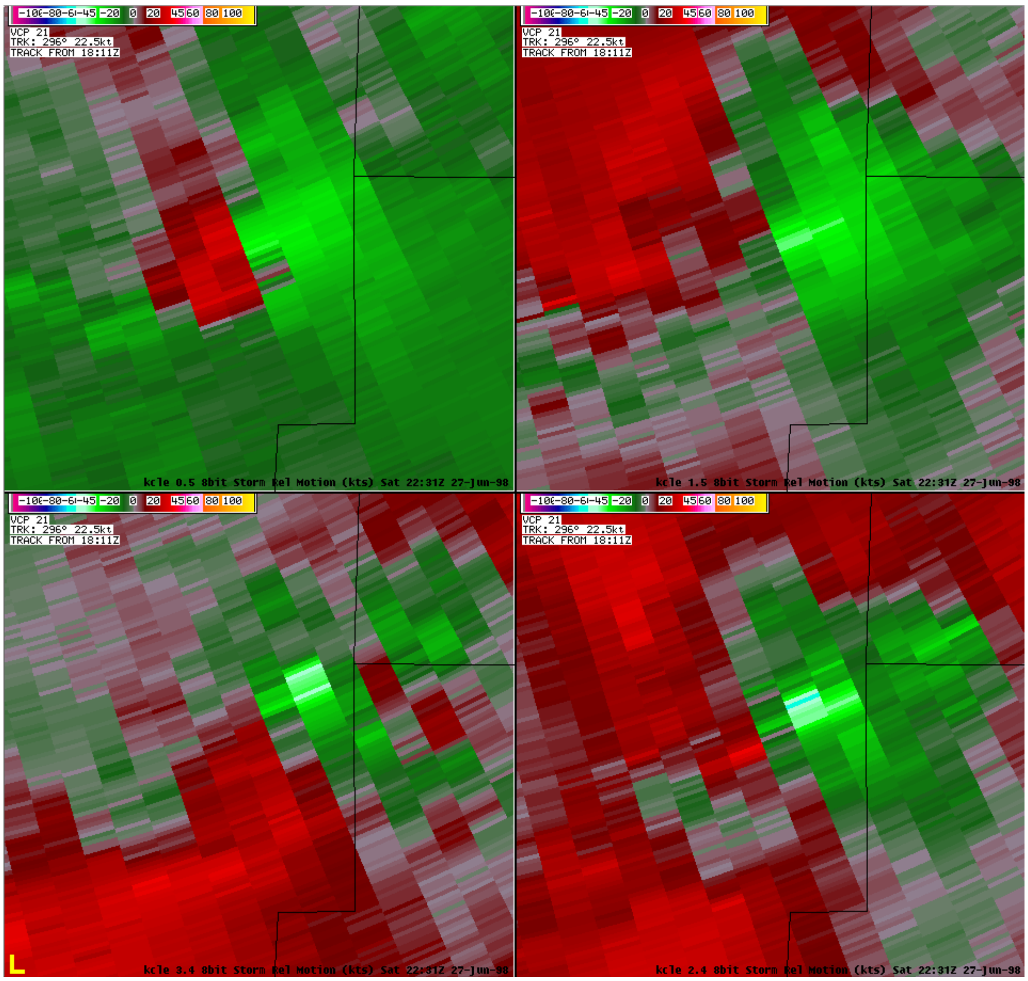
Distance Learning Operations Course



IC 5.5 Base and Derived Products

Presented by

The Warning Decision Training Branch

Version: 0409

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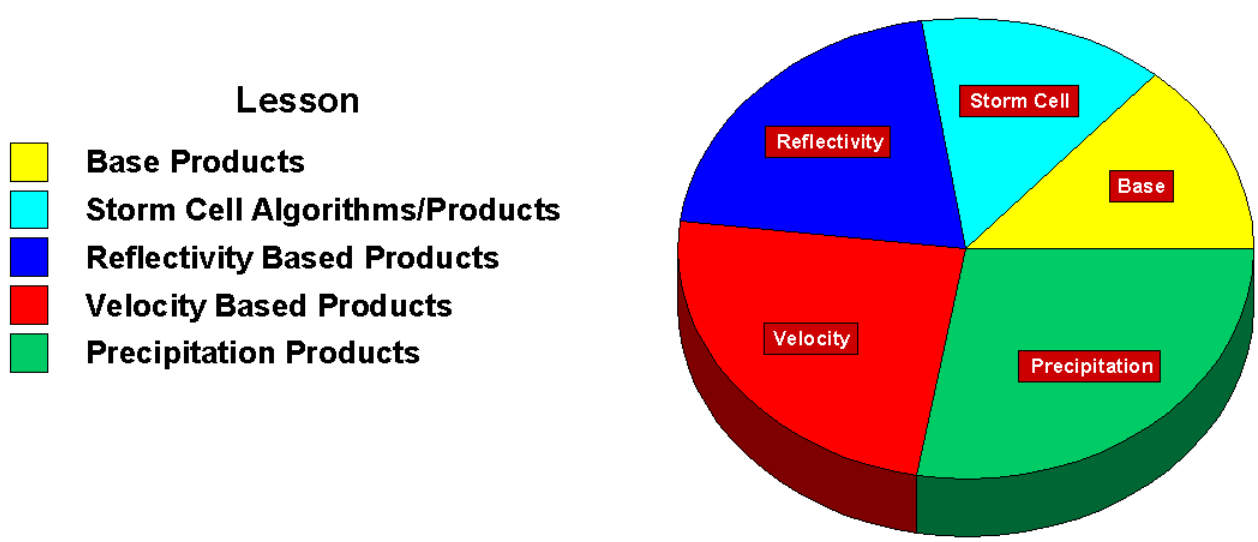
Preface

Overview

Welcome to *Base and Derived Products*! This Student Guide is to be used during the *Base and Derived Products* teletraining session. You should place this in your DLOC student binder. This Student Guide not only contains materials presented in the teletraining presentations, but also practice exercises, and supplemental materials. To most effectively learn the material, it is strongly suggested that after attending teletraining, you do the worksheets and exercises in this Student Guide. After completing the practice exercises, you may want to review this Student Guide before attempting Exam 3.

Prior to taking Exam 3, you should be comfortable with the objectives listed in each of the five lessons of this Student Guide, as well as the answers to review exercises. Worksheets are also provided for those who want a little extra practice.



IC5.5 Objectives

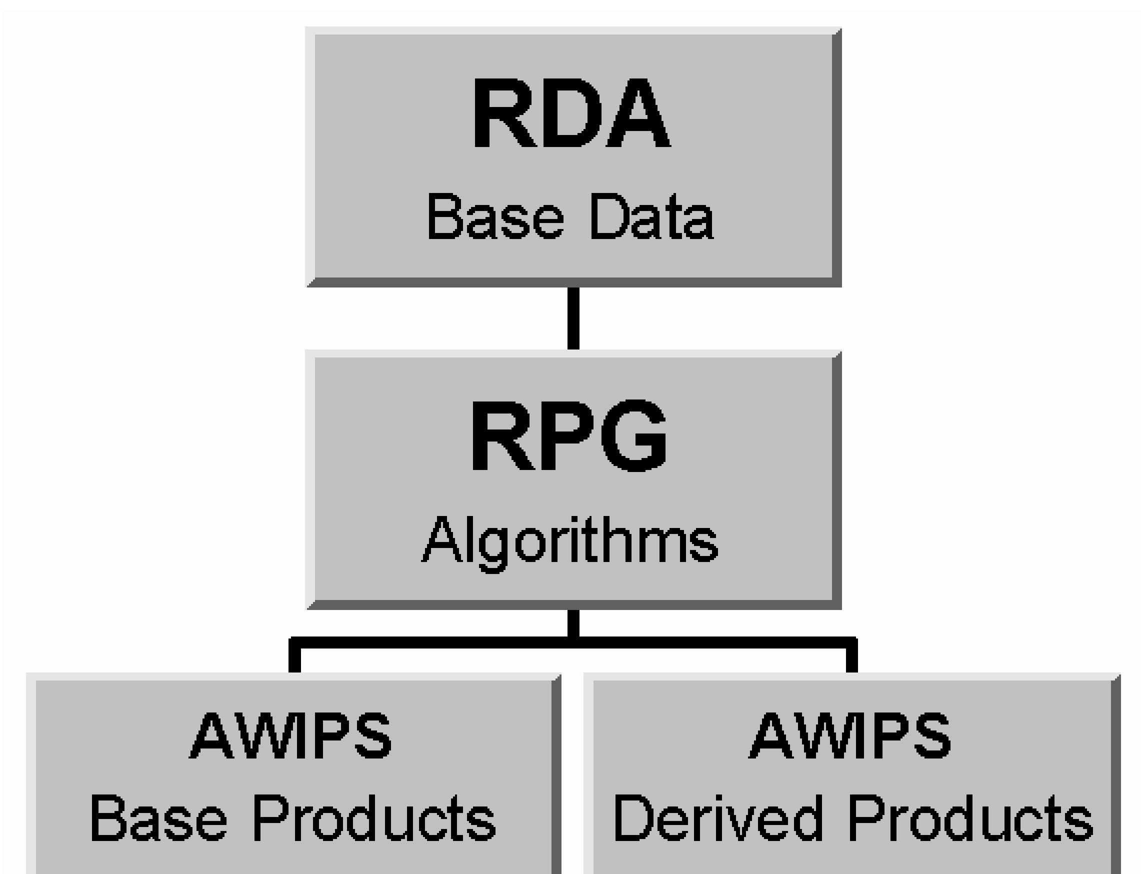
1. Identify specific characteristics of WSR-88D products.
2. Identify limitations of WSR-88D products.
3. Identify specific applications (strengths) of WSR-88D products.

Review

Analog data are sent from Receiver to Signal Processor, and converted to digital base data at the Signal Processor.

Clutter suppression and some range unfolding are completed at the RDA and digital base data is then sent to the RPG via wideband link.

Velocity dealiasing and some additional range unfolding (in VCP 12 and 121) is done at the RPG, then product generation occurs. Products are then sent from the RPG to AWIPS via narrowband link.



Base Products vs Derived Products

Base Products are those that display the three base moments -- reflectivity (Z), velocity (V), and spectrum width (SW). All other WSR-88D products are called Derived Products. Derived Products use meteorological algorithms (computer programs) residing in the RPG or AWIPS to manipulate the base data.

Why use Base Products?

Base products are preferred for analyzing significant meteorological features. Derived products tend to remove or mask many types of important signatures. Base products can be used to determine significant synoptic and mesoscale features, such as fronts and other boundaries, weak echo regions, and heavy snow bands.

Why use Derived Products?

Derived products can assist the user in rapidly analyzing data. It is important to note that the Derived Products are only as good as the algorithms (computer programs) that produce them. Decisions should **never** be based solely on Derived Products. The Derived Products should be used like other types of computer guidance (i.e., MOS).

Using both Base and Derived Products

When possible, base products should be used to verify features found in derived products. When you look at a base product, you are seeing the data used as input for all the derived products, and can use this data to evaluate the derived products. For example, is that heavy precipitation area on the One Hour Precipitation (OHP) product from rain, or from the bright band? At what altitude is the higher reflectivity occurring on the Composite Reflectivity?

More on Base Products

All base products are displayed as a polar coordinate (360° azimuth) color image at approximately one degree beamwidth. Base Products are relative to the RDA. The beam always originates from the RDA and not the location of the operator, or the RPG.

Base products are available for any elevation angle of the current VCP in effect. If the radar is in VCP 12, products are available for all 14 elevation angles. If VCP 31 is current, then only 5 elevation angles are available.

More on Derived Products

The meteorological algorithms used by the WSR-88D vary considerably in their complexity. The numerical manipulations in some algorithms are very complex, while others are simple. Many algorithms become more complex as certain criteria are met.

Adaptable Parameters

It has long been recognized that in different climatological regimes, adjustments may need to be made to the meteorological algorithms. The values (parameters) within an algorithm that can be changed are called the Adaptable Parameters.

There are hundreds of meteorological adaptable parameters in the WSR-88D. Since changing an adaptable parameter may have unexpected results on algorithm output, and in turn affect other algorithms, most meteorological adaptable parameters are ROC controlled, meaning that you do not have the authority to change a value without ROC approval. Almost all of the meteorological adaptable parameters that can be changed at the RPG HCI are password protected.

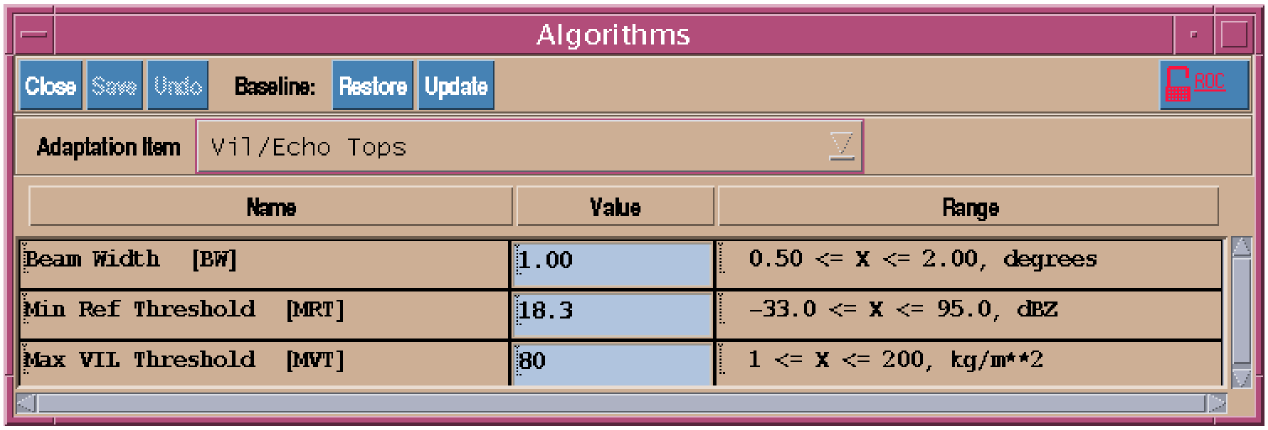


Figure P-1. Here is an example of adaptable parameters within the VIL algorithm (RPG HCI).

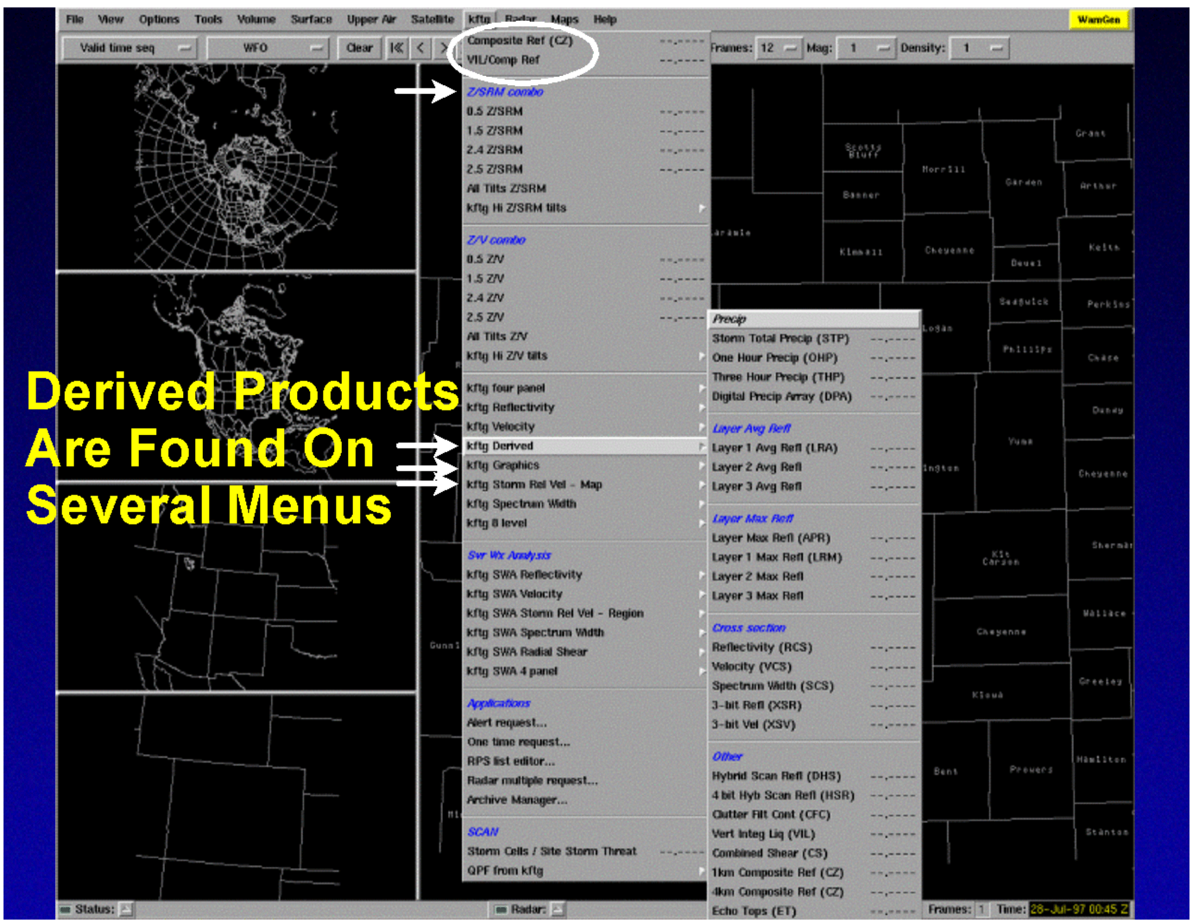


Figure P-2. Derived products are found on several menus on the AWIPS Workstation.

PRODUCTS	Product ID #	Spatial Resolution		Number of Data Levels Available	MAX Range of Product (nm)	Product Coverage (Dimensions)		Load-shed Priority #	Saved on Archive Level 3		RPCCDS Products		NAPUPS	
		nm X	nm or deg			Radius (nm)	nm X nm		Modes: A	B	Modes: A	B	Modes: A	B
Severe Weather Analysis (SWA)														
(SWR) Reflectivity	43	0.54	1 deg.	16	124	----	27 x 27	94	---	---	---	---	---	---
(SWV) Velocity	44	0.13	1 deg.	16	124	----	27 x 27	93	---	---	---	---	---	---
(SWW) Spectrum Width	45	0.13	1 deg.	8	124	----	27 x 27	92	---	---	---	---	---	---
(SWS) Radial Shear	46	0.27	1 deg.	16	124	----	27 x 27	46	---	---	---	---	---	---
Severe Weather Probability (SWP)	47	15.4	15.4	N/A	124	124	------	69	Y	---	---	---	Y	---
Velocity Azimuth Display Profile (VWP)	48	N/A	N/A	5	Default 16	----	------	82	Y6	Y6	Y	Y	Y	Y
Reflectivity Cross Section (RCS)	50	0.54	0.27vertical	16	124	----	------	98	---	---	---	---	---	---
Velocity Cross Section (VCS)	51	0.54	0.27vertical	16	124	----	------	97	---	---	---	---	---	---
Storm-Relative Mean Radial Velocity Region (SRR)	55	0.27	1 deg.	16	124	----	27 x 27	67	---	---	---	---	---	---
Storm-Relative Mean Radial Velocity Map (SRM)	56	0.54	1 deg.	16	124	124	------	68	Y"	---	Y"	---	Y~	---
Vertically Integrated Liquid (VIL)	57	2.2	2.2	16	124	124	------	83	Y	---	Y	---	Y	---
Storm Tracking Information (STI)	58	N/A	N/A	N/A	248	248	------	74	Y	---	Y	---	Y	---
Hail Index (HI)	59	N/A	N/A	5	124	124	------	72	Y	---	Y	---	Y	---
Mesocyclone (M)	60	N/A	N/A	3	124	124	------	71	Y	---	Y	---	Y	---
Tornadic Vortex Signature (TVS)	61	N/A	N/A	2	124	124	------	70	Y	---	Y	---	Y	---
Storm Structure (SS)	62	N/A	N/A	N/A	248	248	------	73	Y3	---	Y	---	Y	---
Layer Composite Reflectivity Average (LRA)	63,64,89	2.2	2.2	8	-51	----	248 x 248	42,42,10	---	---	---	---	---	---
Layer Composite Reflectivity Maximum (LRM)	65,66,90	2.2	2.2	8	-51	----	248 x 248	63,62,61	---	---	Y	Y	Y	---

" = Lowest Tilt ; ~ = Lowest 2 Tilts ; ^ = Lowest 3 Tilits ; * = Lowest 4 tilts

3 = Every Third Volume Scans ; 6 = Every Sixth Volume Scans

PRODUCTS	Product ID #	Spatial Resolution nm X	nm or deg	Number of Data Levels Available	MAX Range of Product (nm)	Product Coverage (Dimensions) Radius (nm)	nm X nm	Load-shed Priority #	Saved on Archive Level 3 Modes: A	B	RPCCDS Products Modes: A	B	NAPUPS Modes: A	B
LRM AP Removed (APR)	67	2.2	2.2	8	124 - 175	----	248 x 248	62	---	---	Y	Y	---	---
Use Alert Message (UAM)	73	N/A	N/A	N/A	N/A	N/A	----	91	----	----	----	----	----	----
Radar Coded Message (RCM)	74	Approx 5 (1/16 LFM)	Approx 5 (1/16 LFM)	9	248	248	------	65	Y	Y	Y	Y	Y	Y
Free Text Message (FTM)	75	N/A	N/A	N/A	N/A	N/A	----	91	----	----	Y	Y	----	----
One Hour Precipitation (OHP)	78	1.1	1 deg.	16	124	124	------	81	Y3	---	Y	---	Y	Y
Three Hour Precipitation (THP)	79	1.1	1 deg.	16	124	124	------	77	---	---	Y	---	Y	Y
Storm Total Precipitation (STP)	80	1.1	1 deg.	16	124	124	------	78	Y3	---	Y	---	Y	Y
Digital Precipitation Array (DPA)	81	Approx 5 (1/40 LFM)	Approx 5 (1/40 LFM)	256	124	124	------	80	Y	Y	Y	---	Y	Y
Supplemental Precipitation Data (SPD)	82	N/A	N/A	N/A	124	----	------	79	Y	Y	Y	---	Y ---	Y ---
Velocity Azimuth Display (VAD)	84	N/A	N/A	8	0.54 - 124	----	------	57	---	---	---	---	---	---
Reflectivity Cross Section (RCS)	85	0.54	0.27vertical	8	124	----	------	50	---	---	---	---	---	---
Velocity Cross Section (VCS)	86	0.54	0.27vertical	8	124	----	------	49	---	---	---	---	---	---
Combined Shear(CS)	87	0.27 to 2.2	1 deg.	16	124	----	124 x 124	39	---	---	---	---	---	---
ITWS Digital Base Velocity (DBV)	93	0.54	1 deg	256	62	62	------	87	---	---	---	---	---	---
Base Reflectivity Data Array (DR)	94	0.54	1 deg	256	248	248	------	35	---	---	---	---	---	---
Base Velocity Data Array (DV)	99	0.13	1 deg	256	124	124	------	34	---	---	---	---	---	---
Clutter Likelihood Reflectivity (CLR)	132	0.54	1 deg	11	124	124	------	87	---	---	---	---	---	---
Clutter Likelihood Doppler (CLD)	133	0.54	1 deg	12	124	124	------	87	---	---	---	---	---	---
Hi Res Digital VIL (DVL)	134	0.54	1 deg	256	248	248	------	80	---	---	---	---	---	---
Super Ob (SO)	136	NA	NA	NA	NA	NA	------	89	---	---	---	---	---	---
User Selectable Layer Reflecticity (USR)	137	0.54	0.54	16	124-175	----	248 x 248	65	---	---	---	---	---	---
Digital Storm Total Precipitation (DSP)	138	1.1	1 deg	256	124	124	------	80	---	---	---	---	---	---

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PRODUCTS	Product ID #	Spatial Resolution nm	X nm or deg	Number of Data Levels Available	MAX Range of Product (nm)	Product Coverage (Dimensions) Radius (nm)	nm X nm	Load-shed Priority #	Saved on Archive Level 3 Modes: A	B	RPCCDS Products Modes: A	B	NAPUPS Modes: A	B
Base Reflectivity (R)	16	0.54	1 deg.	8	124	124	------	56	---	---	---	---	---	---
	17	1.1	1 deg.	8	248	248	------	55	---	---	---	---	---	---
	18	2.2	1 deg.	8	248	248	------	54	---	---	---	---	---	Y"
	19	0.54	1 deg.	16	124	124	------	89	Y"	Y"	Y*	Y*	Y*	Y*
	20	1.1	1 deg.	16	248	248	------	88	Y"	---	Y"	---	Y"	---
	21	2.2	1 deg.	16	248	248	------	87	---	---	---	---	---	---
Mean Radial Velocity (V)	22	0.13	1 deg.	8	32	32	------	53	---	---	---	---	---	---
	23	0.27	1 deg.	8	62	62	------	52	---	---	---	---	---	---
	24	0.54	1 deg.	8	124	124	------	51	---	---	---	---	---	---
	25	0.13	1 deg.	16	32	32	------	86	Y"	Y"	Y"	Y"	Y"	Y"
	26	0.27	1 deg.	16	62	62	------	85	---	---	---	---	---	Y^
	27	0.54	1 deg.	16	124	124	------	84	Y"	Y"	Y*	Y*	Y*	Y*
Spectrum Width (SW)	28	0.13	1 deg.	8	32	32	------	60	Y"	Y"	Y"	Y"	Y"	Y"
	29	0.27	1 deg.	8	62	62	------	59	---	---	---	---	---	Y^
	30	0.54	1 deg.	8	124	124	------	58	Y"	Y"	Y"	Y"	Y*	Y*
User Selectable Precip (USP)	31	1.1	1 deg.	16	124	124	------	57	---	---	---	---	Y	Y
Digital Hybrid Reflectivity (DHR)	32	0.54	1 deg.	256	248	248	------	57	---	---	---	---	---	---
Hybrid Scan Reflectivity (HSR)	33	0.54	1 deg.	16	124	124	------	57	---	---	---	---	Y	Y
Clutter Filter Control (CFC)	34	0.54	1.4 deg.	8	124	124	------	99	Y	Y	Y	Y	Y	Y
Composite Reflectivity (CR)	35	0.54	0.54	8	124	124	------	48	---	---	---	---	---	---
	36	2.2	2.2	8	248	248	------	47	---	Y3	---	Y	---	Y
	37	0.54	0.54	16	124	124	------	76	---	---	Y	Y	---	---
	38	2.2	2.2	16	248	248	------	75	Y3	Y3	Y	Y	Y	Y
Echo Tops (ET)	41	2.2	2.2	16	124	124	------	66	Y3	---	Y	---	Y	---

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3 = Every Third Volume Scans ; 6 = Every Sixth Volume Scans

Lesson 1: Base Products

Objectives

Upon completion of this lesson, you will be able to:

1. Identify specific characteristics of any Base Product.

2. Identify limitations of any Base Product.

3. Identify specific applications (strengths) of any Base Product.

Base Product Color Depth - Data Levels

Base products are available in three different “color depths” each corresponding to a different number of data levels:

- **8-bit = 256 data levels**
- **4-bit = 16 data levels**
- **3-bit = 8 data levels**

Generally, the more data levels the better. Then why have 4-bit and 3-bit base products? The answer lies in file size. The 8-bit (256 data levels) base product files are 4 to 10 times larger than 4-bit (16 data levels) base product files. Therefore, it takes the 8-bit products longer to be transmitted from the RPG to users. If there is a high speed connection, such as the LAN connection between the RPG and co-located AWIPS, numerous 8-bit base products can be made available. For slower speed connections, such as dial-up modems, one 8-bit product can take several minutes to transmit.

In AWIPS, when selecting “Z” from the menu, the 8-bit product will be displayed if it is in the database. Note that some VCP 12 elevation slices are not menu. Selection of the closest value will display those elevation slices (e.g., selection of 3.4 Refl will display 3.2 degree product).

Base Reflectivity (Z)

8-Bit Base Reflectivity Product Characteristics

8-bit Reflectivity Resolution - 0.54 nm x 1 degree

- To generate this data, the power from four successive 0.13 nm bins is averaged. This average power is then converted to dBZs at the RDA. After the base data is created, it is transmitted to the RPG via the wideband link. The

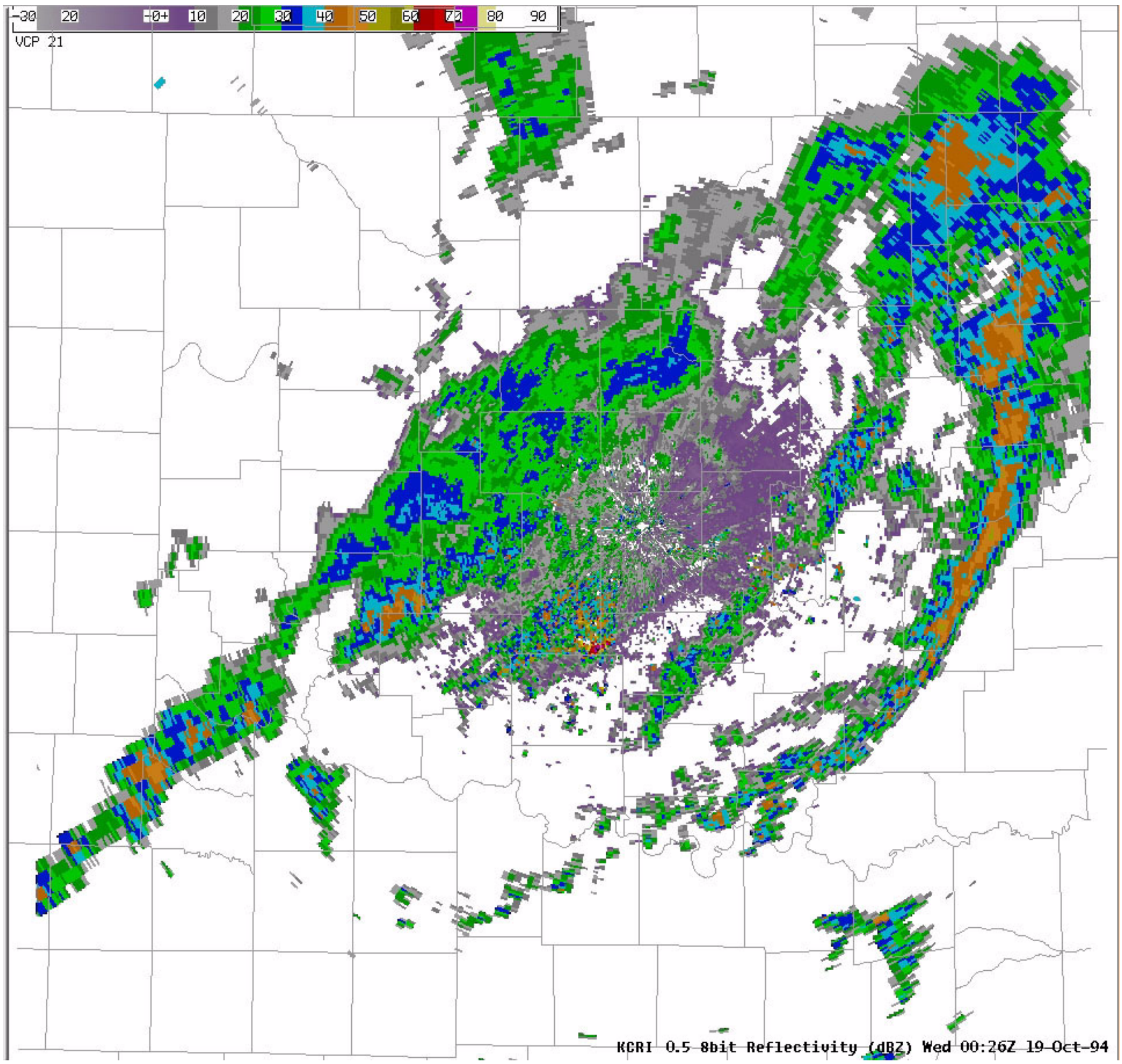


Figure 1-1. This 8-bit Reflectivity product has a maximum range of 248 nm. The resolution is .54 nm out to 248 nm. (.54 nm is the only resolution available for the 8-bit Reflectivity product)

8-bit Reflectivity products produced by the RPG display at 0.54 nm resolution to 248 nm.

8-bit Reflectivity Range - 248 nm

8-bit Reflectivity Data Levels- All VCPs

- 256 Data Levels: -30 dBZ to >90 dBZ
- To the nearest 0.5 dBZ

8-bit Ref product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: x.x in degrees
- PRODUCT NAME: 8-bit Reflectivity
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

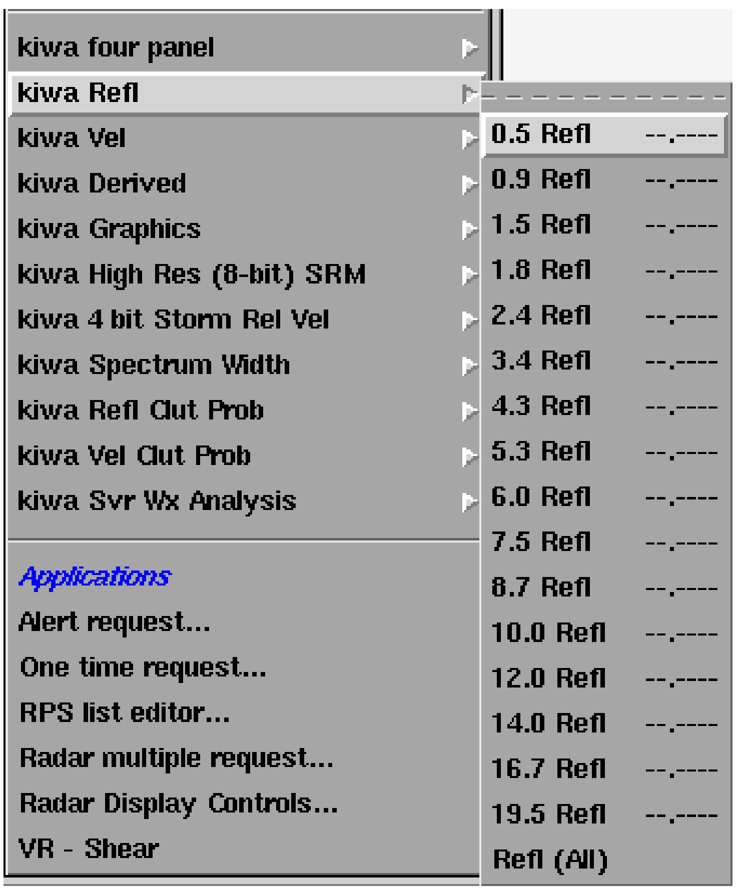


Figure 1-2. 8-bit Reflectivity product menu. Some VCP 12 elevation slices are not on menu. Selection of the closest value will display those elevation slices (e.g., select 3.4 Refl displays 3.2° product)

8-bit Ref product annotations:

- VCP: 11, 12, 21, 121, 31 or 32
- Product Resolution: 1 km (0.54 nm)

4-Bit and 3-Bit Base Reflectivity

The 4-bit (16 data level) and 3-bit (8 data level) base reflectivity products are available at 3 resolutions of 1 degree beamwidth:

- **0.54 nm** (1 km) to 124 nm range
- **1.1 nm** (2 km) to 248 nm range
  - Displays maximum of two consecutive 0.54nm data values
- **2.2 nm** (4 km) to 248 nm range
  - Displays maximum of four consecutive 0.54nm data values

Selecting a 4-bit or 3-bit reflectivity product in AWIPS will display the best resolution product available in the AWIPS data base. For instance, if both the 0.54 nm resolution product and the 1.1 nm product are in the AWIPS database, the display will have 0.54 nm x 1° data out to 124 nm and 1.1 nm x 1° resolution data from 124 nm out to 248 nm.

See Figure 1-3 for an example of a 4-bit (16 data level) Base Reflectivity product.

Implications to the operator

Both 4-bit or 3-bit reflectivity products in AWIPS will display a resolution change at 124 nm range from 0.54 x 1° to 1.1 nm (or 2.2 nm) x 1° (see Fig. 1-3).

Maximum reflectivity is always displayed as resolutions change, preserving important meteorological features (storm cores, etc.). See Figure 1-4.

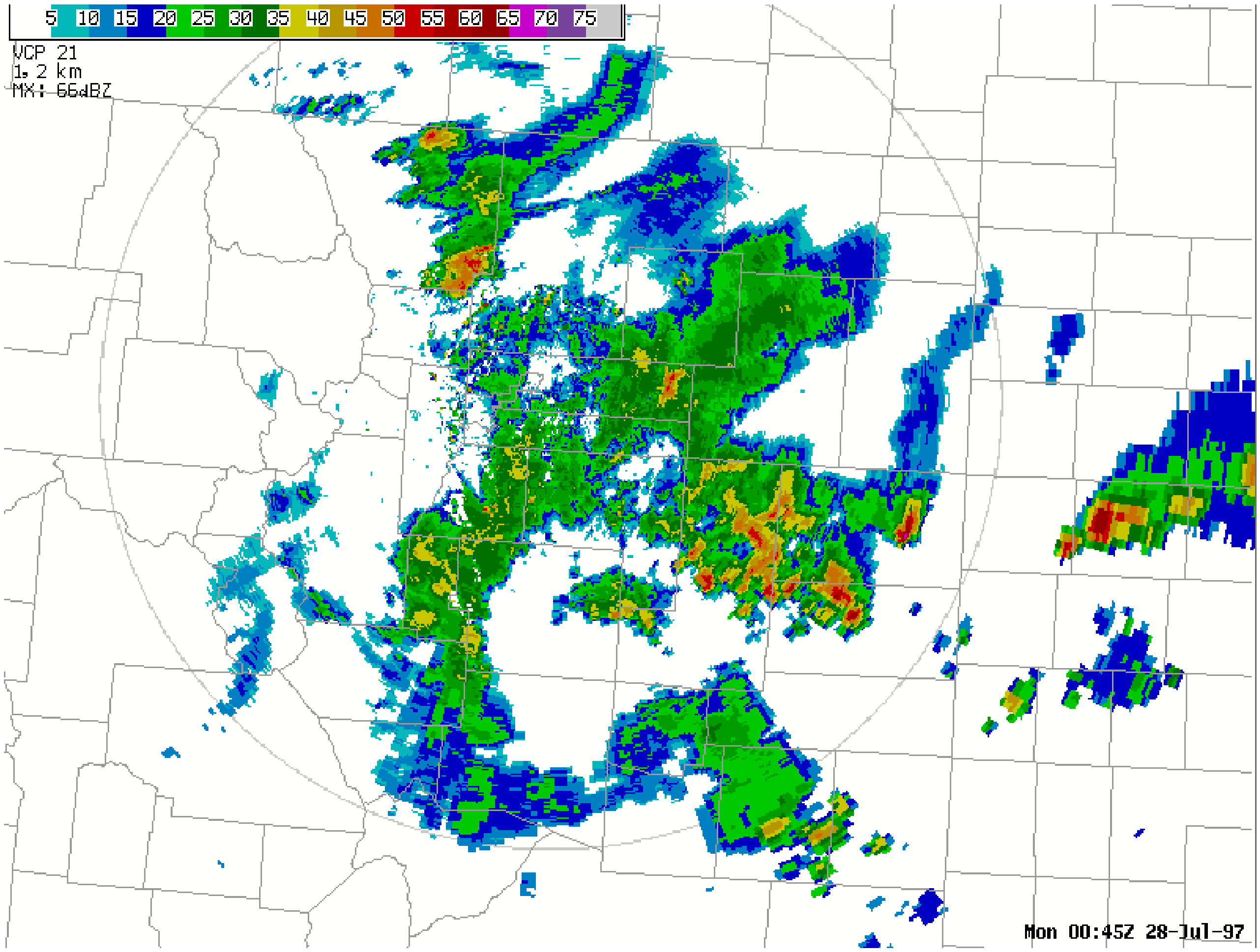


Figure 1-3. Example of displayed resolution differences on a Base Reflectivity product. The 0.54 nm and 1.1 nm resolutions are displayed.

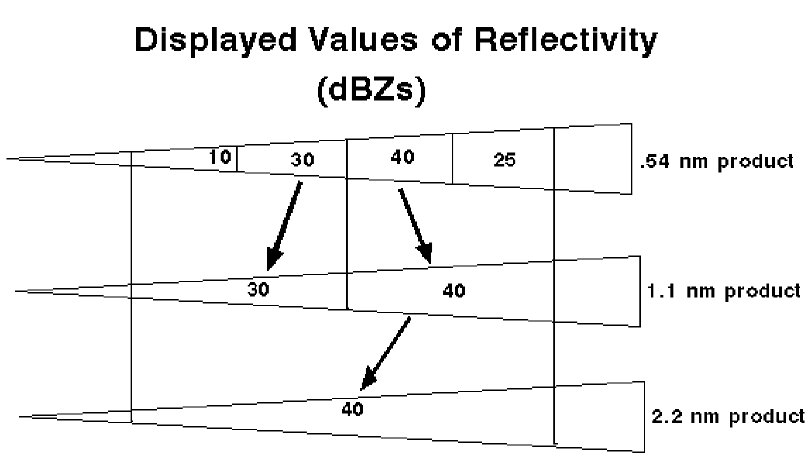


Figure 1-4. Values of reflectivity retained for display on products of different resolutions.

4-Bit and 3-Bit Data Levels

Clear Air Mode (Mode B), VCPs 31 and 32

16 Data Levels range from -28 dBZ to ≥ 28 dBZ
8 Data Levels range from 5 dBZ to ≥ 57 dBZ

Precipitation Mode (Mode A), VCPs 11 and 21

16 Data Levels range from 5 dBZ to ≥ 75 dBZ
8 Data Levels range from 5 dBZ to ≥ 57 dBZ

Note that the data level range of the 3-bit (8 data level) base reflectivity products do not change with VCP changes. Only the 4-bit (16 data level) base reflectivity products change data level values with a change from Precipitation Mode to Clear Air Mode, and vice versa. (See Fig. 1-5 for an example of a clear air reflectivity product.)

Data levels are in dBZ, and are displayed using lower bound thresholds. This means that the numbers beside the color bar in the annotations area of the product are the lowest dBZ values for each color. In Fig. 1-3, the color labeled 35 dBZ can actually range from 35-39 dBZ.

The maximum reflectivity (dBZ) is noted in the product annotation area and may occur anywhere in the product. The location of the maximum reflectivity is **not** displayed.

Base Reflectivity Limitations

1. **Ground Returns**
   - Residual clutter and ground returns from superrefraction may contaminate products.

   Operational Solutions

   - Invoking clutter suppression at the RPG HCI should be the first action an operator takes to reduce ground returns. Base Products can be used to evaluate the Base Data that is being used in all the algorithms. Ground returns not only make Base Products hard to interpret, but

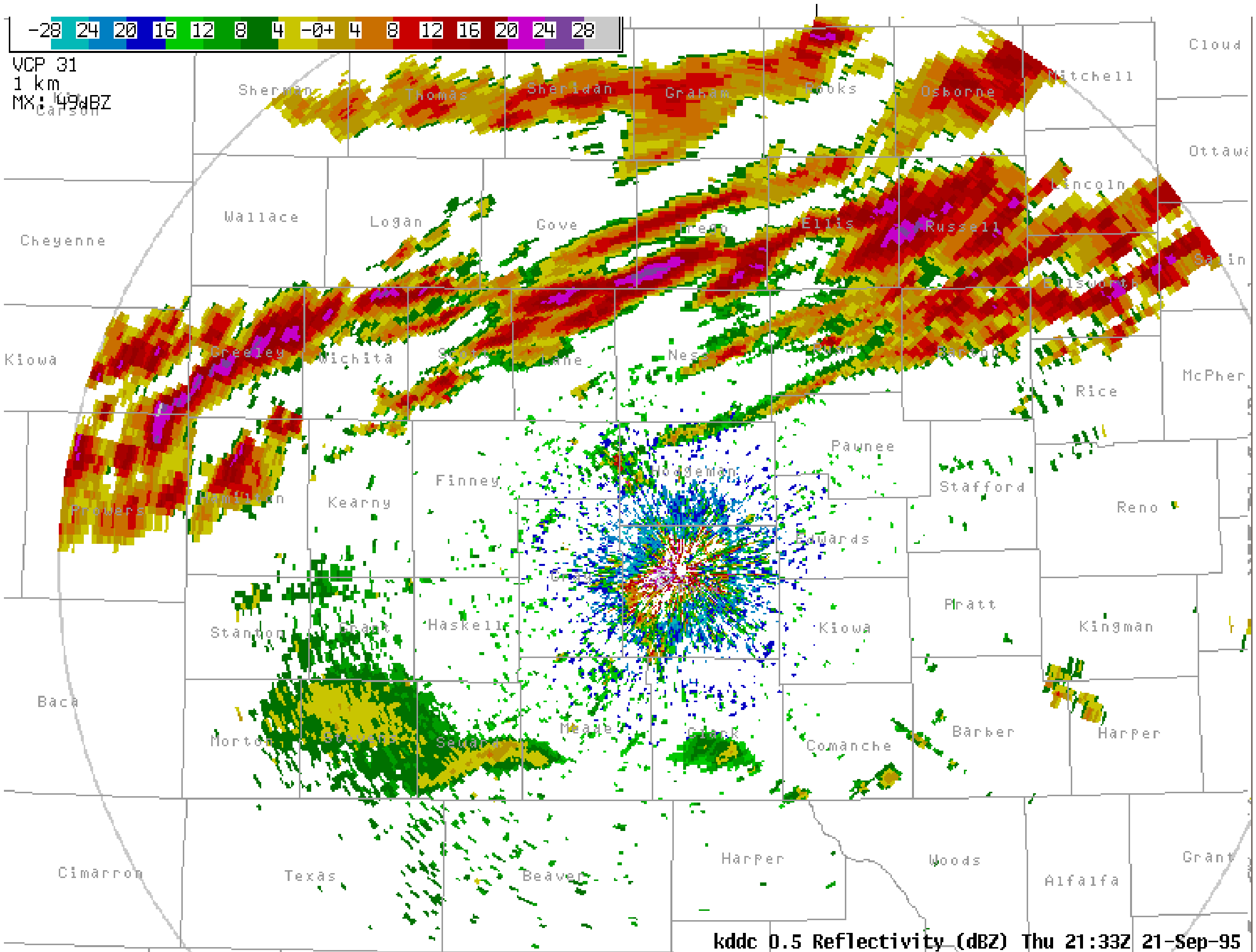


Figure 1-5. Clear Air Mode 4-bit (16 data level) Reflectivity Product.

they can also contaminate the derived products.

- Viewing a higher elevation angle will display data that was sampled above the ground returns.
- An adjacent radar site may not be experiencing superrefraction. Requesting products from that site will help the operator view an area of interest without contamination from AP.

2. Beam Blocking

- Beam blocking is possible especially on lower elevation angles. When sites for the radars were chosen, one of the considerations was to minimize blockage of the beam. Unfortunately, that is not possible at every radar site.

Operational Solution

- Solutions to beam blockage are choosing a higher elevation angle to overshoot the target that is blocking the radar beam, or requesting products from an adjacent site to view the areas that are being obscured.

3. Resolution vs. Range

- Beam broadening leads to poor resolution at longer ranges.

Operational Solution

- Call another site closer to the return.

4. Effects of Earth Curvature

- Beam centerline increases in altitude with range. The radar may then overshoot significant features at low levels and far ranges.

Operational Solution

- Access a closer radar that samples the feature at lower altitudes. Be aware of the importance of spotter input at these far ranges.

5. Effects of Discrete Elevation Sampling

- Echoes may be poorly sampled by the VCP in use depending on range and echo geometry. A small storm at far ranges will be poorly sampled compared to the same storm close in. In addition, a close storm will be more poorly sampled in VCP 21 than VCP 12.

Operational Solution

- If possible, operate in VCP 12 when echoes are present. This VCP will better sample storms both at far and near ranges.
- Accessing other radars may show the same storm at different altitudes.

6. Cone of Silence

- Data are unavailable for higher altitudes close to the RDA. The highest elevation angle is 19.5^{o} in VCPs 11, 12 and 21 and 121. Data above 19.5^{o} is not available for display on any of the Base Products.

Operational Solution

- If applicable, request Base Products from an adjacent site to display data in the cone of silence where data are needed.

7. Chaff

- Chaff may cause large areas of non-meteorological echoes. It is detected by radar after being dropped from airplanes, and begins with initial returns in a small area between 20 and 40 dBZ. The returns at first resemble pulse type thunderstorms, and can be very confusing to a radar operator. Over time, the chaff will spread out with the mean wind flow both horizontally and vertically. It will slowly decrease in intensity to very low dBZs. It is characterized on the radar as an elongated echo.

Operational Solution

- Review all types of observation systems to make a determination on chaff. Satellite, surface observations, other radar sites, and spotters are tools that can be used.
- Watch for high dBZ during initial release, with gradual decrease in intensity, spreading with mean wind flow, and vertical dispersion.
- Look for reoccurrence over the same areas upwind of flight routes, military operations areas etc.
- Military points of contact are often unable to disclose chaff drops. During an exercise the

decision may be up to the pilot to drop chaff, and is not necessarily a coordinated scheduled chaff release.

Base Reflectivity Applications (Strengths)

1. **Observe precipitation intensity, movement and trends.**
   - Base reflectivity has been the standard output from radars for the past 50 years, and remains one of the most useful outputs from the WSR-88D.
   - Precipitation products use base reflectivity. Therefore, reflectivity products can be used for validation and quality control of precipitation products.
   - The use of Clear Air Mode can be extremely useful during winter storm events with detection of heavier snow bands.
2. **Determine significant storm structure features.**
   - Several storm structure features can be readily identified using base products including Weak Echo Regions (WER), Bounded Weak Echo Regions (BWER), hooks, Rear-Inflow Jet or Weak echo channels, and differing supercell characteristics just to name a few.
3. **Determine location and motion of fronts and other boundaries**.
   - 8-bit 0.5 degree base products are the best radar products to use for boundary detection.
   - Finelines on base reflectivity products indicate boundaries such as gust fronts.
   - If possible, use base products in clear air mode for increased sensitivity. Base Reflectivity in clear air mode will display reflectivities down to -30 dBZ, allowing the operator to see features with low returns such as fronts and drylines.

4. **Locate and identify the melting level.**
   - A melting level of uniform height can be identified as a ring, or partial ring, of slightly higher reflectivity values in the Reflectivity product. If the height of the melting level varies with range from the radar, the ring will be asymmetric and/or the melting level may appear as an arc or as an irregular band.
5. **Identify non-meteorological phenomena.**
   - Many non-meteorological phenomena can be detected on the radar. Bird, bat and insect flight patterns may be viewed. The radar can be used to track range fires as well as locate possible areas where forest fires have started. Furthermore, the radar will be useful to locate volcanic ash, airplanes, chaff droppings and even speeders on the highway. As an operator, you must be constantly aware of the potential for non-meteorological phenomena detection. Remain alert and always use all resources possible to make a determination on what you are viewing.

Base Mean Radial Velocity (V)

8-Bit Base Velocity Product Characteristics

See Figure 1-6 on page 20.

8-bit Velocity Resolution - 0.13 nm x 1 degree

8-bit Velocity Range - 124 nm.

8-bit Velocity Data Levels - All VCPs

- 256 Data levels: > 100 kts inbound/outbound
- Negative values represent inbound velocities
- Positive values represent outbound velocities

8-bit Velocity product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: x.x in degrees
- PRODUCT NAME: 8-bit Velocity
- UNITS: kts
- DATE: Day of week, time, and date in UTC

8-bit Velocity product annotations:

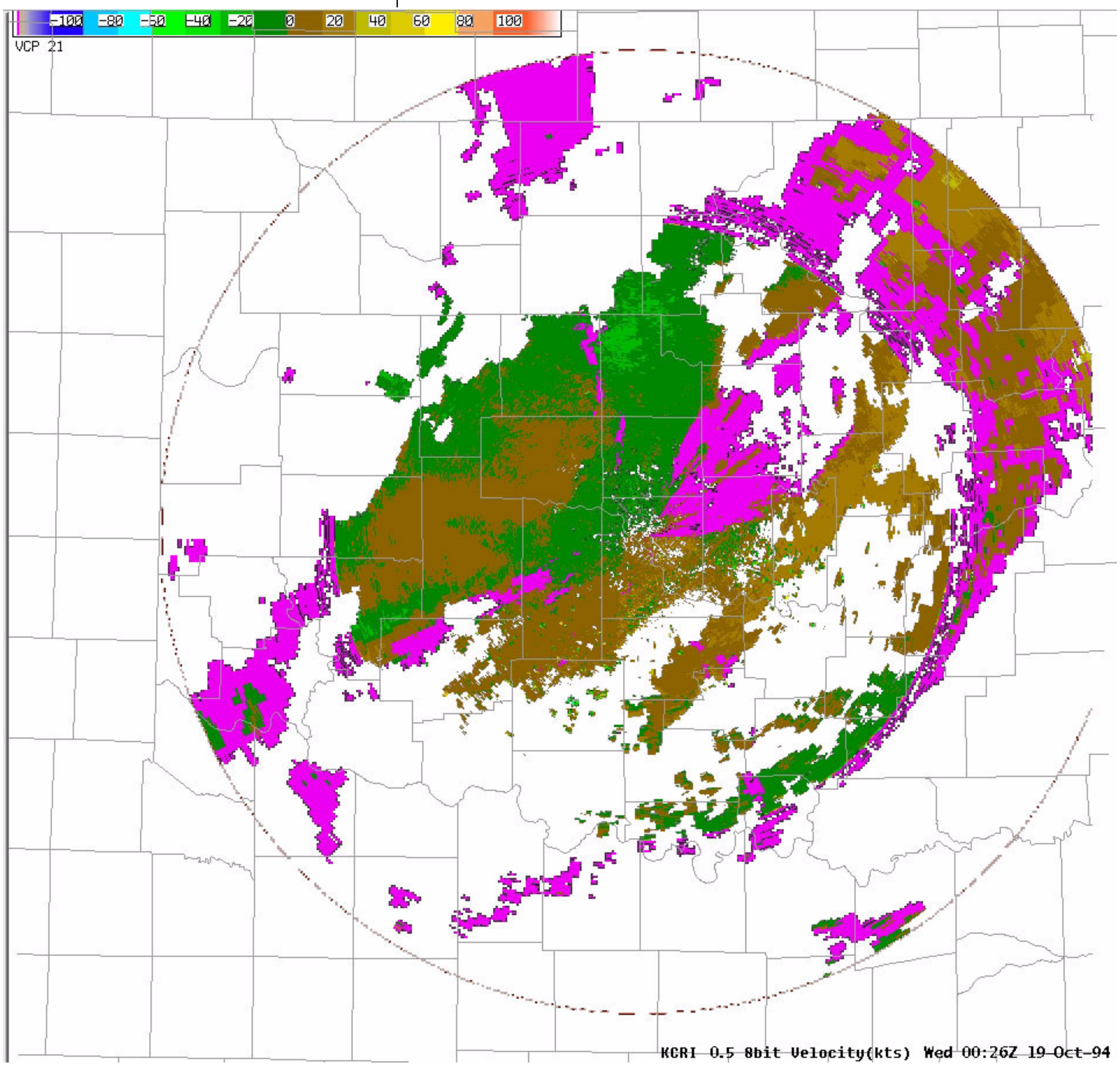


Figure 1-6. This 8-bit Velocity product has a maximum range of 124 nm. The resolution is.13 nm out to 124 nm. (.13 nm is the only resolution available for the 8-bit Velocity product)

- VCP: 11, 12, 21, 121, 31 or 32
- Product Resolution: 0.25 km
- MN - Minimum (inbound): xx kts
- MX - Maximum (outbound): xx kts

Velocity increment

For velocities less than 124 kts, an increment of 0.97 kts can be invoked at the RPG HCI. This allows the display of velocities up to + / -123 kts in one kt increments. To display velocities up to 246 kts, the velocity increment of 1.94 kts must be

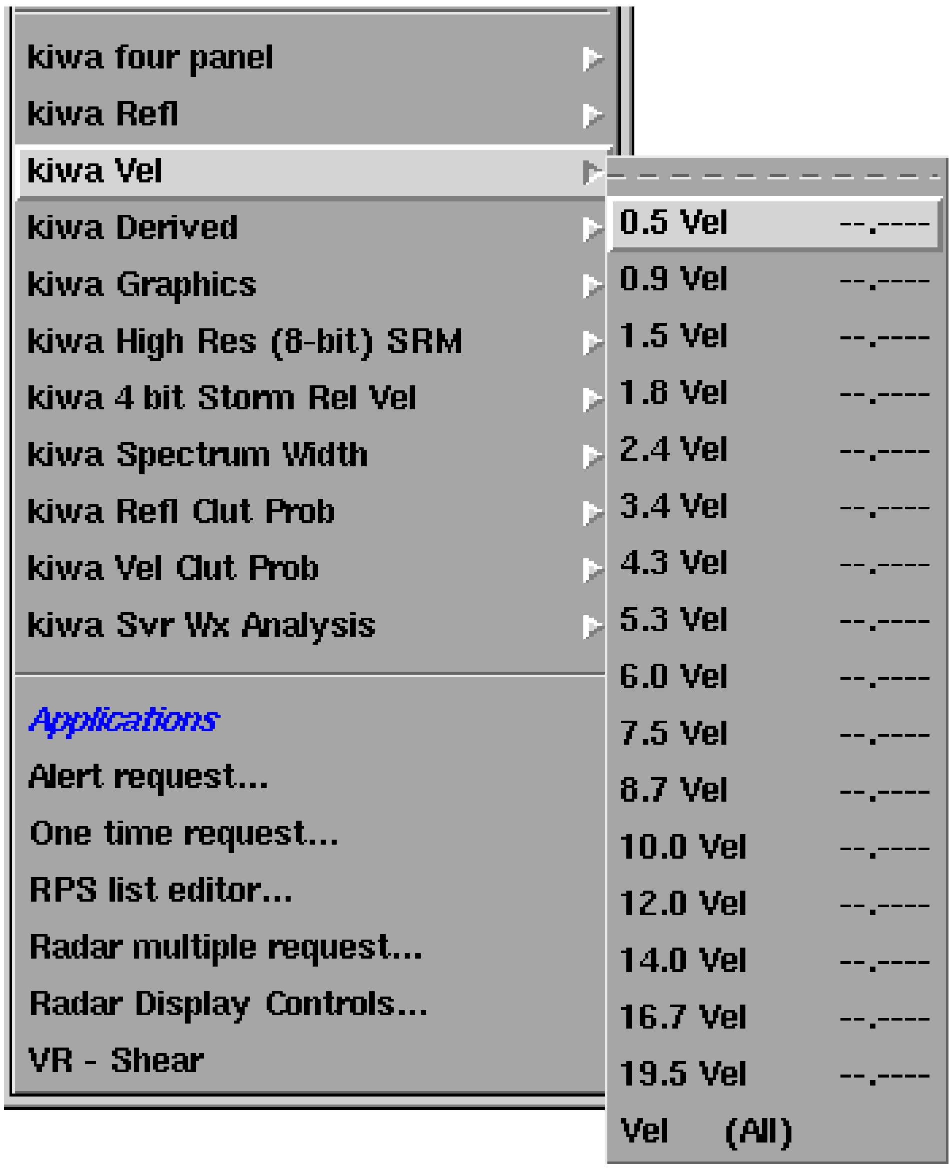


Figure 1-7. 8-bit Velocity product menu.Selection of the closest value will display those elevation slices (e.g., select 3.4 Refl displays 3.2^{o} product)

invoked at the RPG HCI. This allows the display of velocities up to + / -246 kts in two kt increments.

4-bit and 3-bit Base Velocity

The 4-bit (16 data level) and 3-bit (8 data level base velocity products are available at three resolutions to three ranges (see Fig. 1-8 on page -22):

- 0.13 nm (0.25 km) x 1° to 32 nm
- 0.27 nm (0.5 km) x 1° to 62 nm
- 0.54 nm (1.0 km) x 1° to 124 nm

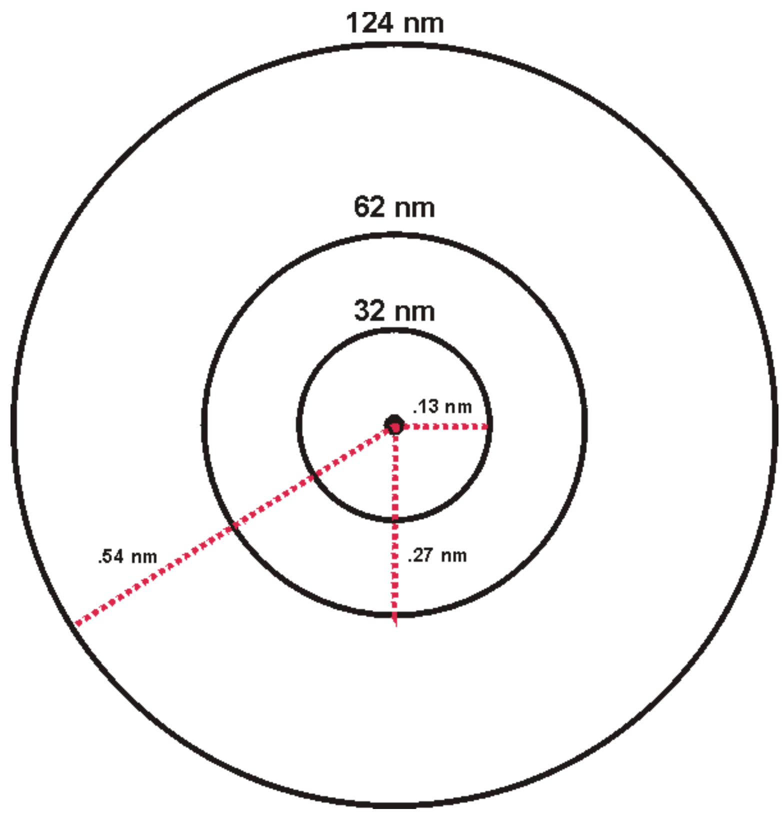


Figure 1-8. AWIPS display of 4-bit and 3-bit Base Velocity uses three different resolutions as available.

Generation

Figure 1-9 shows the method of choosing which data value will be used for display at lower resolutions. The 0.13 nm resolution product displays all 0.13 by 1° data. For the 0.27 nm resolution product the first of two consecutive 0.13 nm data values is displayed. The 0.54 nm resolution product displays the first of four consecutive 0.13 nm data values.

Implications to the operator

As seen in Figure 1-9, because of this display method, echoes on these products will appear differently at various ranges with different resolutions. In contrast to reflectivity, even though the maximum velocity and spectrum width values are listed in the annotations area, they may not be displayed in the data on lower resolution products. This is because for the 0.27 nm and 0.54 nm resolution products, the maximum velocity and spectrum width values may have been ignored in selecting the first of the 0.13 nm range bins for display.

As with Base Reflectivity, AWIPS will display a Base Velocity product with the highest resolution available at each range, if the appropriate ranges are in the database.

4-Bit and 3-Bit Data Levels

Default values for the base velocity data levels:

- 4-Bit (16 data levels) -64 to 64 knots
- 3-Bit (8 data levels) -10 to 10 knots

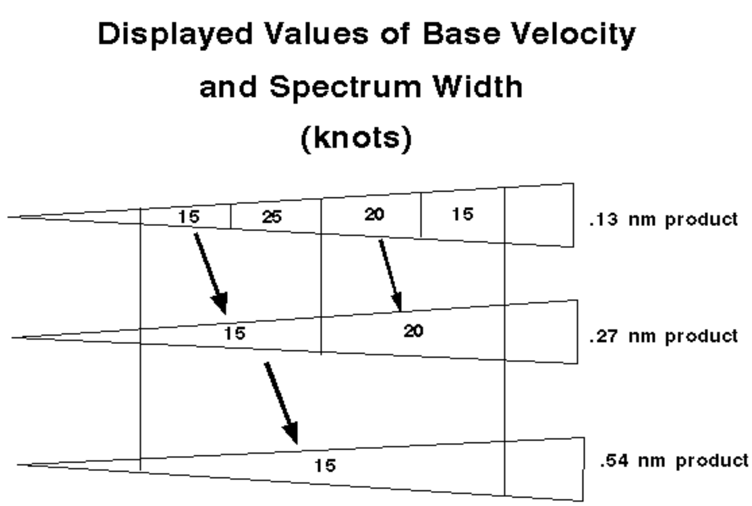


Figure 1-9. Values of velocity and spectrum width retained for display on products of different resolutions.

Data levels are displayed using lower bound thresholds. The numbers beside the color bar in the status and annotations area of the product are the lowest values in knots for the color. In Figure 1-10, the color beside 35 kts (outbound) actually represents the range from 35 to 49 kts. The color next to - 35 kts (inbound) represents the range from - 35 to - 49 kts.

Changing data levels

Base Velocity data levels can be changed at the RPG HCI. Velocity data levels may be changed to highlight certain significant meteorological situations, such as severe thunderstorm criteria, low level jets, tropical storms, and gap and chinook winds in mountainous regions.

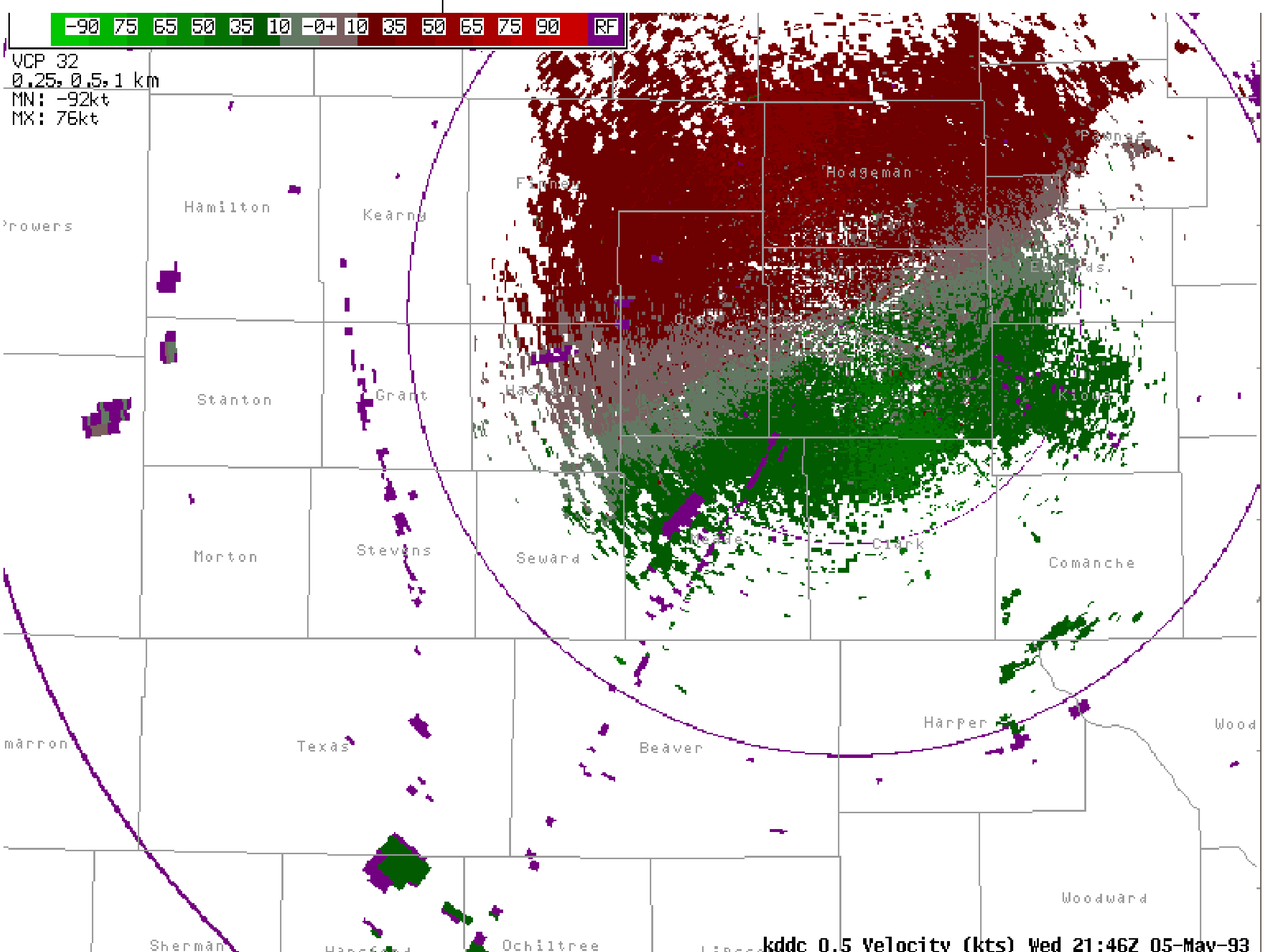


Figure 1-10. Example of displayed resolution differences on a velocity product. All three resolutions 0.13 nm,.27 nm and.54 nm are displayed. The purple range rings mark the resolution changes.

The data level colors may be changed at the AWIPS workstation.

Base Mean Radial Velocity Product Limitations

1. Range folding may obscure data

- Recall from Radar Principles that the range unfolding algorithm compares the ratio of the power return from two targets separated by the maximum unambiguous range (R_{max}) to TOVER. If the ratio exceeds TOVER, the algo-

Figure 1-11. 4Bit Product Menu

rithm assigns velocity data to the target with the strongest power return. If the ratio does not exceed TOVER, neither echo is assigned the velocity value, which will then be designated as ambiguous and range folded. In many cases, range folding may obscure needed velocity data.

Operational Solutions

- The radar operator has several options. If the area of interest is obscured by range folding, the RPG HCI operator can adjust the Pulse Repetition Frequency (PRF). This will change the R_{max}, and possibly move the range folding away from the area of interest. The available PRF numbers, 4 through 8, can place R_{max} from 94 to 63 nautical miles.
- Changing VCP to VCP 121 can dramatically reduce range folding. The Multiple PRF Dealiasing Algorithm used in VCP 121 is specifically designed to reduce range folding.
- Range folding may be caused by nearby ground returns that are obscuring data in the second trip. Invoking appropriate clutter suppression at the RPG HCI will reduce the power associated with the ground returns. The area of interest at the second trip may then be the dominant return. If TOVER is exceeded, the 2nd trip return will then be given a usable velocity value.
- Selecting a higher slice may overcome range folding problems, especially if an area of interest in the first trip is being obscured by data in the second trip. By choosing a higher elevation angle, the beam may overshoot the target in the second trip, and display usable velocity data for the area of interest in the first trip.
- The operator may dial in to another site for a different look at the same storm. For example,

the WSR-88D at Indianapolis, IN may be experiencing range folding problems with a storm to their east. The same storm may not be range folded when viewed from the Wilmington, OH WSR-88D.

2. **Improper velocity dealiasing may display erroneous velocity values.**

- The Velocity Dealiasing Algorithm checks each first guess velocity value with neighboring bins. As a last resort, the dealiasing algorithm compares the velocity data to the environmental winds. Failures occur due to lack of surrounding data, or an out of date environmental winds table.

Operational Solutions

- The RPG HCI operator should ensure the Environmental Winds Table represents the atmospheric flow. Keeping the environmental winds table representative should minimize dealiasing failures especially in VCP 31, where V_{max}=22 kts. It will also prevent initial dealiasing failures from propagating through numerous radials.
- Increasing the PRF at the RPG HCI will increase V_{max}, and decrease the amount of aliased velocities. The dealiasing algorithm will have fewer velocities to dealiase, and less chance for error.
- The same problem may not show up on a different elevation slice.
- Changing VCP to VCP 121 not only reduces range folding but can also reduce velocity dealiasing failures.
- The user can request products from another site for a different look at the same storm. An adjacent site may not be having the same dealiasing problem.

Base Mean Radial Velocity Product Applications/Strengths

1. **Magnitude**
   - Estimate magnitude of radial velocities. Ground relative wind speeds can be estimated for use as input into warnings, statements, and forecasts.
2. **Atmospheric Structure**
   - Determine radial velocity patterns to infer atmospheric structure. Veering or backing winds with height can identify warm air or cold air advection. Low level or mid level jets can be easily identified on the base velocity product.
3. **Storm Structure**
   - Determine radial velocity patterns to infer storm structure. Cyclonic and anticyclonic rotation, storm top divergence, divergence at the surface from microbursts, low level convergence, and the MARC (Mid Altitude Radial Convergence) signature all can be determined from the Base Velocity Product.
4. **Hodographs**
   - Aid in creating, adjusting, or updating hodographs. Hodographs can be created not only for the sounding location or the RDA, but also in the vicinity of a nearby boundary. Wind profiles can be determined to update the hodograph to reflect any changes that may have occurred between soundings.

Base Spectrum Width (SW)

Base Spectrum Width Product Characteristics

Spectrum Width Resolution - 0.13 nm x 1 degree

Spectrum Width products are only available as 3-bit (8 data level) products. As with reflectivity and velocity, AWIPS will display a Spectrum Width product using the best resolution data available in the database. The three resolutions and corresponding ranges of Base Spectrum Width are 1° beamwidth by:

- 0.25 km / 0.13 nm - Range 32 nm
- 0.50 km / 0.27 nm - Range 62 nm
- 1.0 km / 0.54 nm - Range 124 nm

Spectrum Width product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: x.x in degrees
- PRODUCT NAME: Spectrum Width
- UNITS: kts
- DATE: Day of week, time, and date **in UTC**

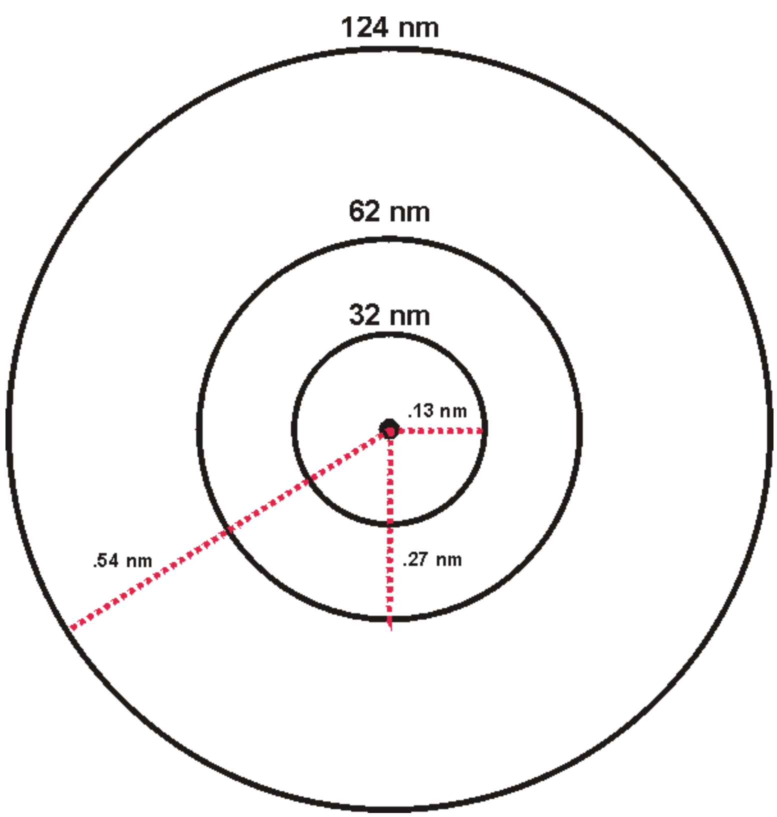


Figure 1-12. The Base Spectrum Width product uses three different resolutions as available.

Spectrum Width product annotations:

- VCP: VCP 11, 12, 21, 121, 31 or 32
- Product Resolution: 0.13 nm (0.25 km), 0.27 nm (0.5 km), and 0.54 nm (1.0 km)
- Max Value: MX xx kt
  - The location of the maximum spectrum width (0.13 nm resolution) is not displayed and may not be visible in the product.

Spectrum Width Data Levels - 8 data levels from 0 to 20 knots.

- Data level values for Spectrum Width do not change with operational mode change. Data levels are displayed using lower bound thresholds.
- Maximum spectrum width is truncated at 19 knots. Spectrum Width values above 19 knots are above the maximum theoretical wideband noise value. Since these values are system related and not data related, they are not displayed.

Typical values

High base spectrum width values result from large velocity differences within a range bin. High velocity differences can result from turbulence, wind shear, differing fall velocities, or from non-meteorological factors.

Stratiform Precipitation

For stratiform precipitation, one would not expect large dispersions in the range bin. Typical spectrum width values for stratiform precipitation are low, in the 0 to 7 kt range.

Turbulent Flow

More variations in the range bin will occur in returns from turbulent areas, such as thunderstorms and outflow boundaries. In those areas, one can expect to see spectrum width values above 8 kts.

Melting Level

Differing fall velocities of rain, wet snow, and snow in the melting level will result in a typical spectrum width of 8 kts.

Base Spectrum Width Product Limitations

1. Range Folding

- As with the Base Velocity Product, range folding may obscure needed spectrum width data.

Operational Solutions

- The same solutions for overcoming range folding in base velocity apply to spectrum width as well. Changing the PRF, invoking clutter suppression, viewing a different elevation angle, and requesting products from another site are all options available to the radar operator.

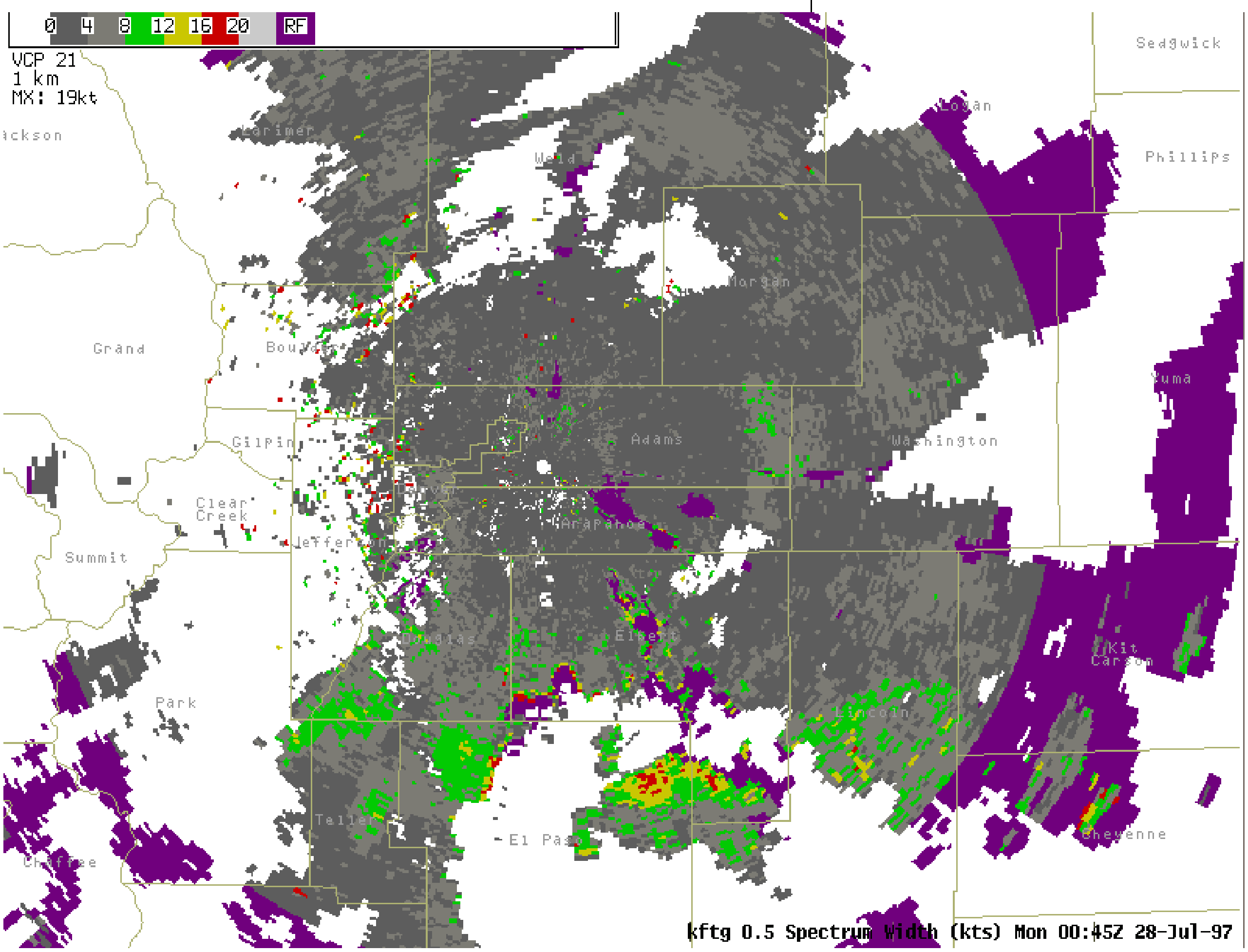


Figure 1-13. Base Spectrum Width.

2. **Ground Clutter**

- Movement of ground clutter may result in high spectrum width values. For example, cars on the road and blowing leaves on trees in the summer can contribute to high velocity variances in the range bin. Turbulent flow around ground targets such as buildings and water towers may also result in high spectrum widths.

Operational Solution

- Invoke appropriate clutter suppression at the RPG HCI for the area of concern.

3. **System Noise**

- Although Base Spectrum Width is truncated at 19 kts to eliminate system noise, spectrum widths from returns near the noise threshold may lead to erratic values. These will be most noticeable as high (12 kt or greater) spectrum widths scattered throughout clear air returns.

Operational Solutions

- Try a higher elevation angle or make a request from another site.

4. **Transmission Time**

- Large amount of time is required to send Base Spectrum Width products down the narrowband line.

Operational Solutions

- If Base Spectrum Width is not used often, limit the number of slices on the RPS list. Do one-time requests for additional elevation angles as needed.
- A second solution is to change to a lower resolution. A 0.54 nm Base Spectrum Width typically has less data to display than a 0.13 nm or

0.27 nm product, and will take less time to transmit down the narrowband line.

Base Spectrum Width Product Applications (Strengths)

1. Evaluate Velocity

- Spectrum width can be used to evaluate the reliability of Base Mean Radial Velocity products. Generally speaking, a higher spectrum width value implies more uncertainty in the velocity estimate. ***This may indicate, but does not necessarily mean that the displayed velocity is incorrect***.
- WSR-88D operators need to look at all the Base Products to determine if the velocity data are accurate. For example, if a Base Velocity Product has strong inbound velocities next to strong outbound velocities, with associated Spectrum Widths > 12 kts, the radar operator should check reflectivity data as well. The velocity signature may be expected after looking at storm structure.

2. Locate suspected areas of turbulence and shear regions

- Shear and turbulence are meteorologically significant. One example of an intense shear region is near the top of a thunderstorm in association with storm top divergence. An 8 data level Base Velocity product can be useful for locating areas where storm top divergence is occurring. Changing the color levels to highlight the highest two velocities can help. Rapid changes in speed and direction seen on the Base Velocity Product can help locate areas of vertical shear that may be hazardous to aircraft.
- Conversely, updraft cores are relatively smooth and display low spectrum widths. Thus, low spectrum width values can indicate regions of updraft in a convective storm.

Interim Summary

Base Reflectivity (Z)

1. Base Reflectivity is the workhorse product of the WSR-88D. It can be used for:
   - observing precipitation intensity, movement, and trends,
   - determining significant storm features,
   - locating and determining the motion of fronts and other boundaries,
   - observing non-meteorological phenomena,
2. When using Base Reflectivity products keep in mind the impacts of radar limitations:
   - Ground Returns
   - Beam Blockage
   - Resolution vs. Range
   - Effects of Earth Curvature
   - Effects of Discrete Elevation Sampling
   - Cone of Silence
   - Chaff

Base Mean Radial Velocity (V)

1. Base Velocity products are extremely valuable product for estimating ground relative wind speeds, vertical wind structure, small scale circulations, storm top divergence, microbursts, etc.
2. Interpretation of Base Velocity products is hampered by range folding and improper velocity dealiasing. These problems can be mitigated by changes to PRF, use of VCP 121 (MPDA), selection of different elevations and radars.

Base Spectrum Width (SW)

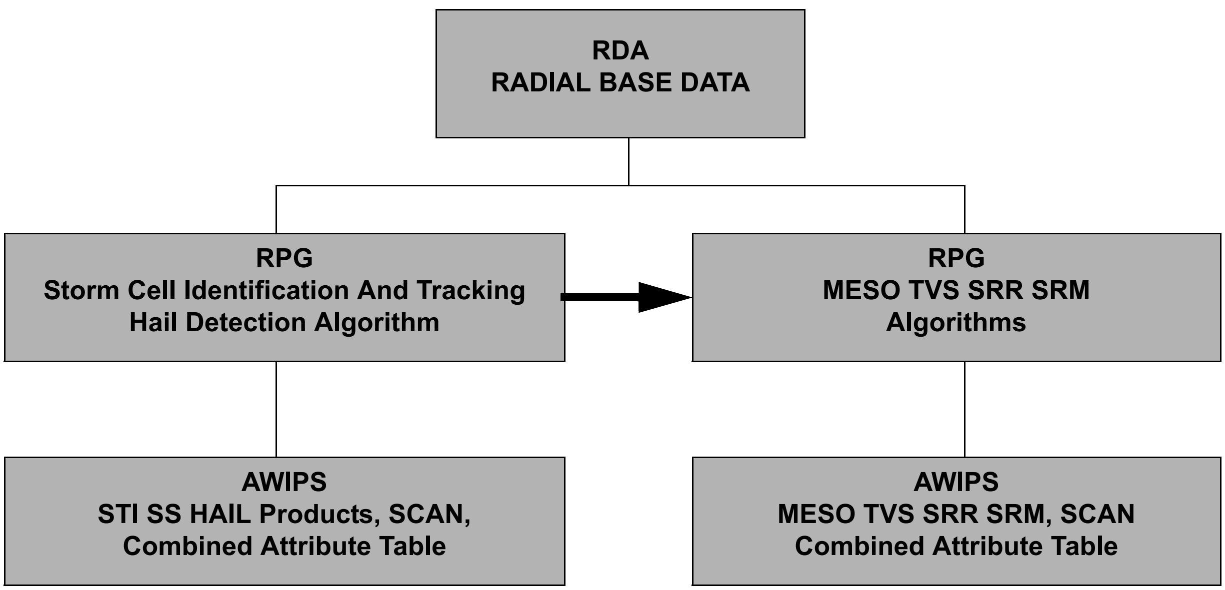
1. Base Spectrum Width is useful for evaluating the reliability of Base Velocity and locating areas of suspected turbulence and shear or the lack of turbulence and shear.
2. Spectrum width values are impacted by range folding, ground clutter, and system noise.

Lesson 2: Storm Cell Algorithms and Products

Overview

This lesson describes how the Storm Cell Identification and Tracking (SCIT) algorithm identifies, tracks and forecast the movement of storm cells. Certain attributes of the identified cells are then utilized by the Hail Detection Algorithm (HDA) to calculate probabilities of hail and severe hail, and to estimate maximum hail size. Descriptions and a listing of limitations and strengths are included for the following:

1. **Storm Track Information** (STI - product #58),
2. **Hail Index** (HI - product #59), and



Objective

Upon completion of this lesson, you will be able to identify specific characteristics, limitations, and applications (strengths) of the following products:

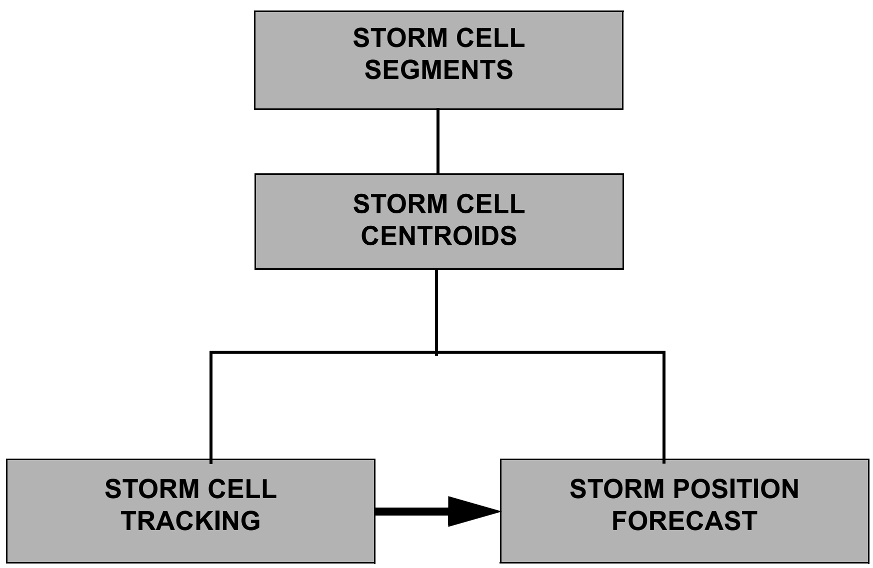
1. Storm Tracking Information (STI) product, and
2. Hail Index Product (HI).

Storm Cell Identification And Tracking (SCIT)

The objective of the Storm Cell Identification and Tracking (SCIT) algorithm is to identify, track, and forecast the movement of storm cells. The primary graphic product produced by this algorithm is Storm Track Information (STI - Product ID # 58).

Data developed by this algorithm are used extensively as input to several other products (i.e., HI, SS, SRM, SRR, MD, TVS, RCM, CR Combined Attribute Table) and applications such as the System for Convection Analysis and Nowcasting (SCAN).

Note: SCAN will **not** be discussed in this section, but will be covered in the DLOC Workshop



SCIT Algorithm Overview

The SCIT algorithm consists of four subfunctions: Storm Cell Segments, Storm Cell Centroids, Storm Cell Tracking, and Storm Position Forecast. The **Storm Cell Segments** subfunction identifies the radial sequences of reflectivity (segments), and outputs information on these segments to the **Storm Cell Centroids** subfunction. The **Storm**

Cell Centroids subfunction groups the segments into two-dimensional components, vertically correlates these components into three-dimensional cells, and calculates these cells' attributes. The cells and their attributes are output to Storm Cell Tracking and Storm Position Forecast. **Storm Cell Tracking** monitors the movement of the cells by matching cells found in the current volume scan to the cells from the previous volume scan. **Storm Position Forecast** predicts future centroid locations based on a history of the cell's movement.

Storm Cell Segments

Definition

Segment - a run of contiguous range bins along a radial with reflectivity values greater than or equal to a specified threshold.

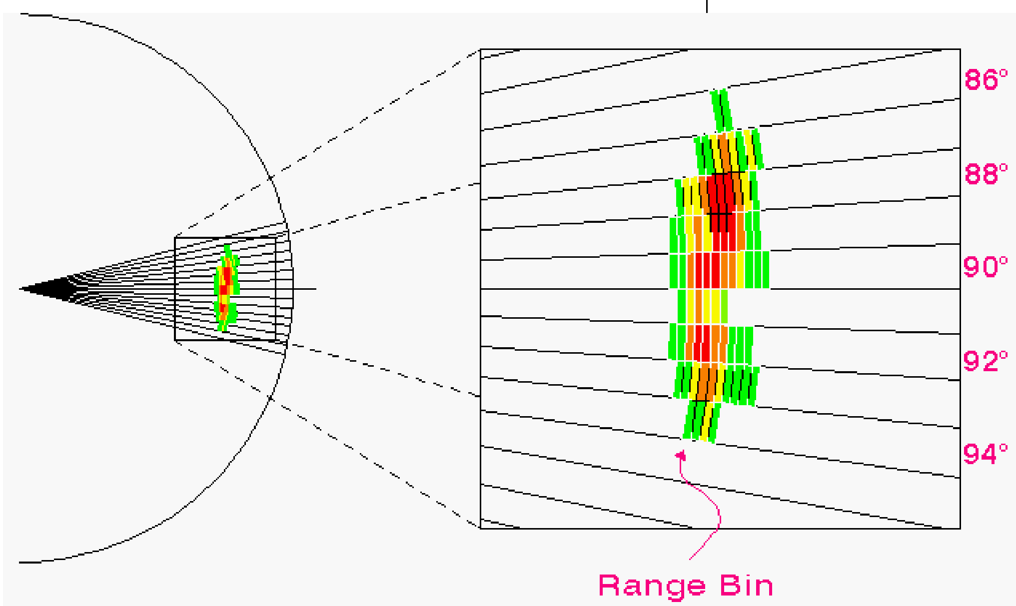


Figure 2-1. Looking closer at the radials, you can see how the reflectivity information is quantified. The basic measurements of reflectivity are made in 1° X.54nm ***range bin***. The function of this algorithm is to combine the individual range bin into storm segments along the radial. Note the segments in the figure.

Process

The Storm Cell Segments subfunction searches for segments of up to seven different **minimum reflectivity thresholds** (See Fig. 2-2 on page 39.). The segment must have a length greater than a **minimum segment length**, and may contain a specified **dropout number** of contiguous range bins that are within the **dropout reflectivity difference** below the minimum reflectivity threshold. The default values of the adaptable parameters are:

- Minimum Reflectivity Thresholds = 30, 35, 40, 45, 50, 55, 60, dBZ
- Minimum Segment Length = 1.9 km (1.1 nm or two range bins),
- Dropout Reflectivity Difference = 5 dBZ, and
- Dropout Number = 2.

The *Storm Cell Segments* subfunction searches for segments on each radial as the data arrives at the RPG. First, a search is done for segments using the lowest minimum reflectivity (default is 30 dBZ). All other range bins are discarded from further processing. Then a search is made of the detected (30 dBZ) segments for segments of the next minimum reflectivity threshold (35 dBZ). Then a search of those (35 dBZ) segments is made for segments of the next threshold (40 dBZ), and so on through the seventh threshold (60 dBZ).

A portion of a radial is depicted in the graphic on the next page and annotated with the reflectivity values of each (1° x 0.54 nm) range bin. Given the default values of the adaptable parameters, seven segments would be defined.

As can be seen from the example, numerous segments could be identified along a single radial. To reduce the processing task, the number of segments of a given threshold is limited to 15 (adaptable parameter) per radial. In other words, there is a potential for up to 105 segments on a single

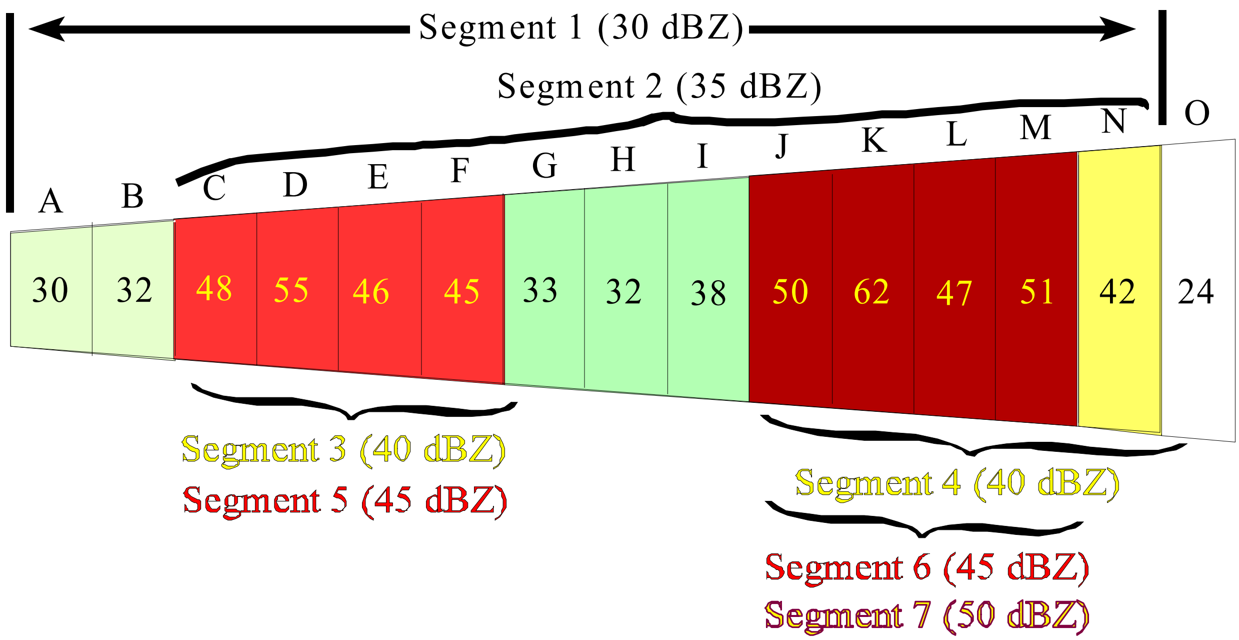


Figure 2-2. In the initial search for a 30 dBZ segment (labeled Segment 1), only the range bin labeled "O" would be eliminated. Segment 2 ("C" through "N") would be selected in the search for 35 dBZ segments (range bins "G" and "H" would remain since up to two contiguous range bins within 5 dBZ of the minimum reflectivity threshold can be contained in the segment). The 40 dBZ segments would include Segment 3 ("C through F") and Segment 4 ("J through N"). Segments 5 and 6 would be defined as 45 dBZ segments, and Segment 7 would be further defined as a 50 dBZ segment. Note that range bin "D" (55 dBZ) and range bin "K" (62 dBZ) would not be considered separate segments since they do not exceed the minimum segment length.

radial (7 thresholds X 15 segments per threshold). Investigations have shown that these thresholds will only be exceeded in very active weather situations.

Storm Cell Centroids

Definitions

Component - A two-dimensional area of combined segments on a single elevation slice.

Centroid - A three dimensional location of a cell's center of mass.

Process

At each elevation slice, the Storm Cell Centroids subfunction groups adjacent segments of each reflectivity threshold into two-dimensional components. If components overlap, the component with the higher reflectivity is saved and the other(s) dis-

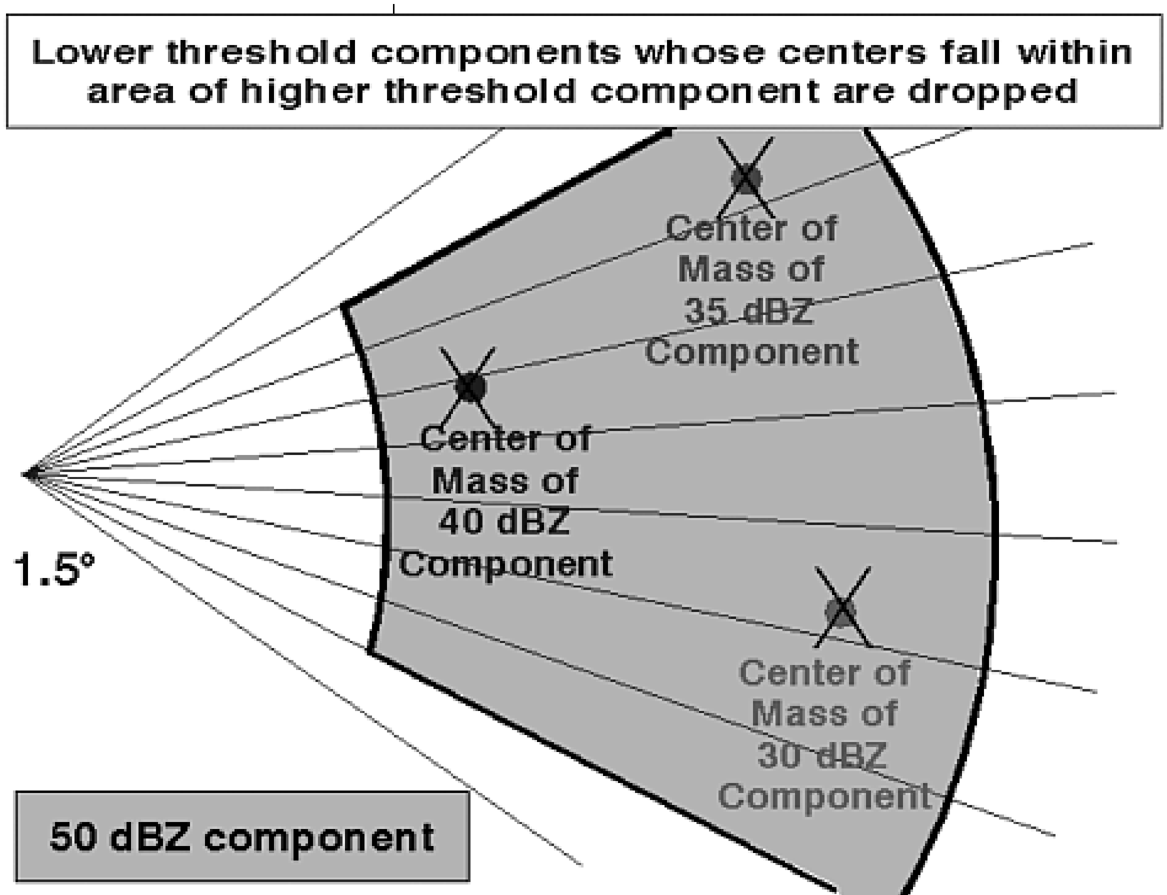


Figure 2-3. Storm Cell Centroid Processing

carded. ***Only the smaller "bull's eyes" of high reflectivity are saved for correlation into three-dimensional cells***. Therefore, cells are defined by their areas of highest reflectivity.

The components are vertically correlated by comparing the proximity of the centers of every component with those in adjacent elevation scans. Components with the largest masses are compared first. If at least two components are vertically correlated, a cell is created.

Storm Cell Centroids Output

For each identified cell the following attributes are calculated:

- centroid (in polar coordinates),
- height of the centroid (ARL - Above Radar Level),

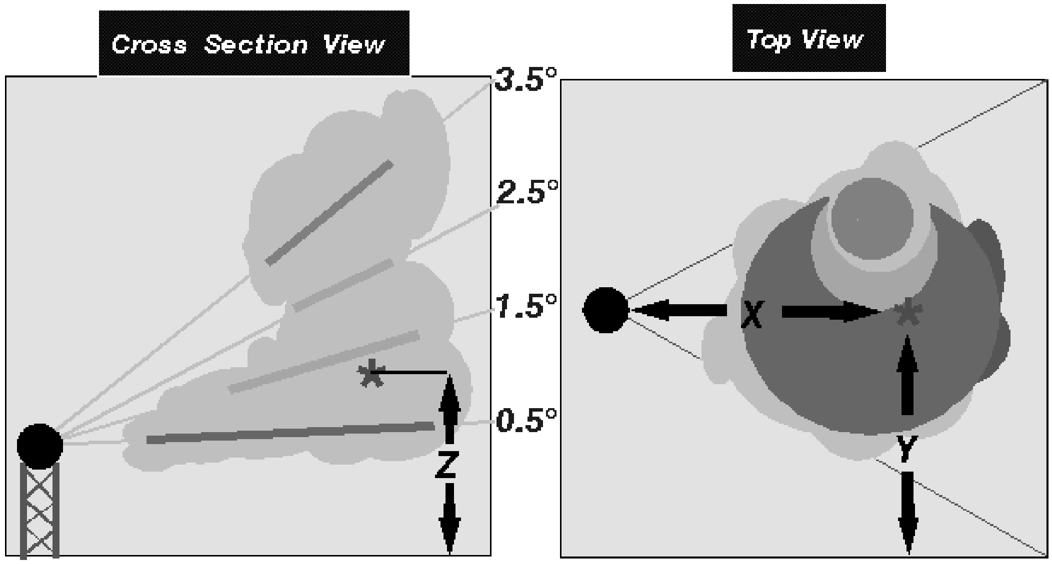


Figure 2-4. Centroid Locations

- maximum (3-bin averaged) reflectivity,
- height of the maximum reflectivity (beam centerpoint height - ARL),
- cell base and top (ARL),
- number of components, and
- Cell-based Vertically Integrated Liquid (VIL).

Cell-based VIL

A calculation of VIL is made for each cell identified by Storm Cell Centroids by vertically integrating maximum reflectivity values of a cell's correlated components. This is a **different** calculation than the gridded VIL product (VIL - Product ID #57). As can be shown on the following example (See Fig. 2-5 on page 42.), a fast-moving or highly tilted storm will usually have a higher Cell-based VIL than Grid-based VIL.

Up to **100 cells** can be identified by Storm Cell Centroids. The cells are ranked by Cell-based VIL. Cell-based VIL is displayed in SCAN, the Storm Structure Alphanumeric Product, and the Composite Reflectivity Combined Attributes Table.

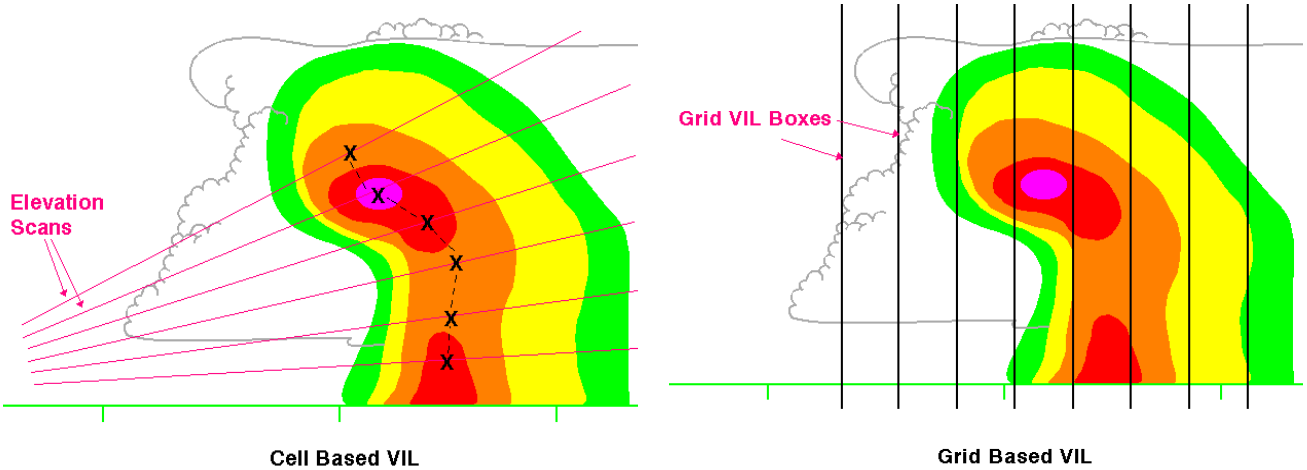


Figure 2-5. Cell-based vs. Grid-based VIL.

Storm Cell Tracking

Process

Storm Cell Tracking monitors the movement of storm cells by matching cells found in the current volume scan to the cells from the previous volume scan. Starting with the cell with the highest Cell-based VIL, a comparison is done of its centroid location with the projected (based on past movement) centroids from the previous volume scan. The closest projected centroid within a threshold distance (speed limitation) is considered the same cell (See Fig. 2-6 on page 43.).

If a correlation is made, the cell is given the same ID as in the previous volume scan. If no correlation is made, the cell is given a new ID. The ID assigned to a Cell consists of a letter-number combination (A0, B0, C0... Z0, A1, B1... Z1, A2, B2... Z9). This adds some value to the ID, such as cell R7 has been identified longer than cell H8 (**the number has precedence over the letter in this scheme**). The list of IDs will reset to begin with A0 when the RPG is rebooted, or when a threshold time interval has lapsed without cells.

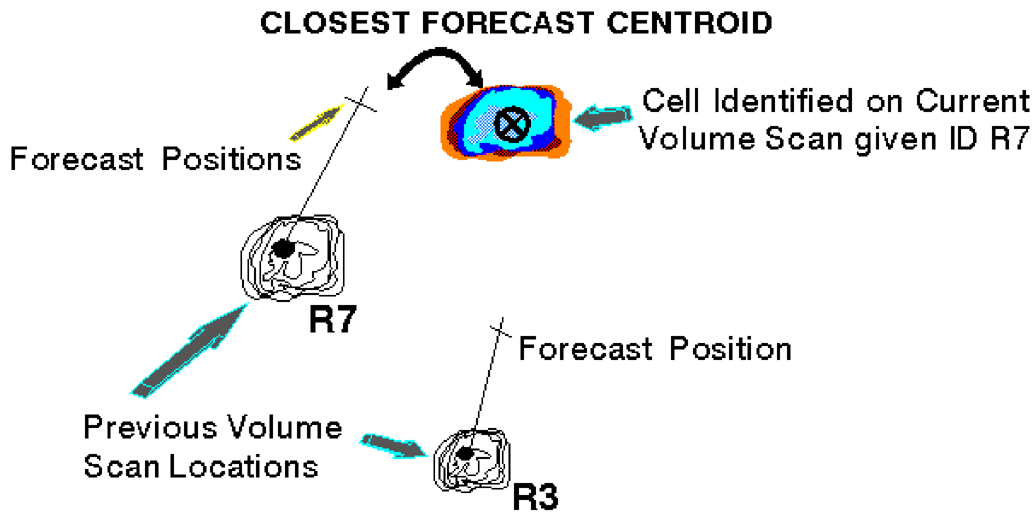


Figure 2-6. Storm Tracking Process. Centroid location is compared with forecast location of centroids from the previous volume scan.

Storm Position Forecast

Process

Storm Position Forecast predicts the future centroid locations of cells based on a history of the cell's movement. The first time a cell is detected it is labeled a new cell, and the forecast movement used by the algorithm for processing purposes is either:

a) the average movement of all identified cells, or

b) if no other cells are identified, the default speed and direction as set at the RPG HCI.

Subsequently, each time the cell is detected, a prediction is made using a linear least squares extrapolation of the cell’s previous movement. A comparison of the current centroid location is made to the previous forecast position, with the duration of the forecast (0, 15, 30, 45, or 60 minutes) dependent on the magnitude of this departure. In other words, the larger the error in the past volume scan forecast, the shorter (in time) the forecast.

Storm Track Information Graphic Product

Product Description

Data developed by the SCIT algorithm is directly input to the Storm Track Information Product (STI - Product ID #58). The STI product can display up to 100 cells identified by the SCIT algorithm on a single product. It is also possible to display the actual past positions of the centroid on up to 13 (default 10) previous volume scans. Cells with a movement of less than a minimum speed (default 5 kts) are circled to indicate little movement, and past positions and forecast tracks are not displayed. The following symbols are displayed on the product:

⊗ centroid location,

• past position (volume scan increments with a line between each symbol), and

\+ forecast position (15 minute increments with a straight line connecting all forecast positions),

⊗ stationary (<5 kts).

STI Product Characteristics

See Figure 2-7 for an example of the STI product.

STI product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Storm Track Info
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

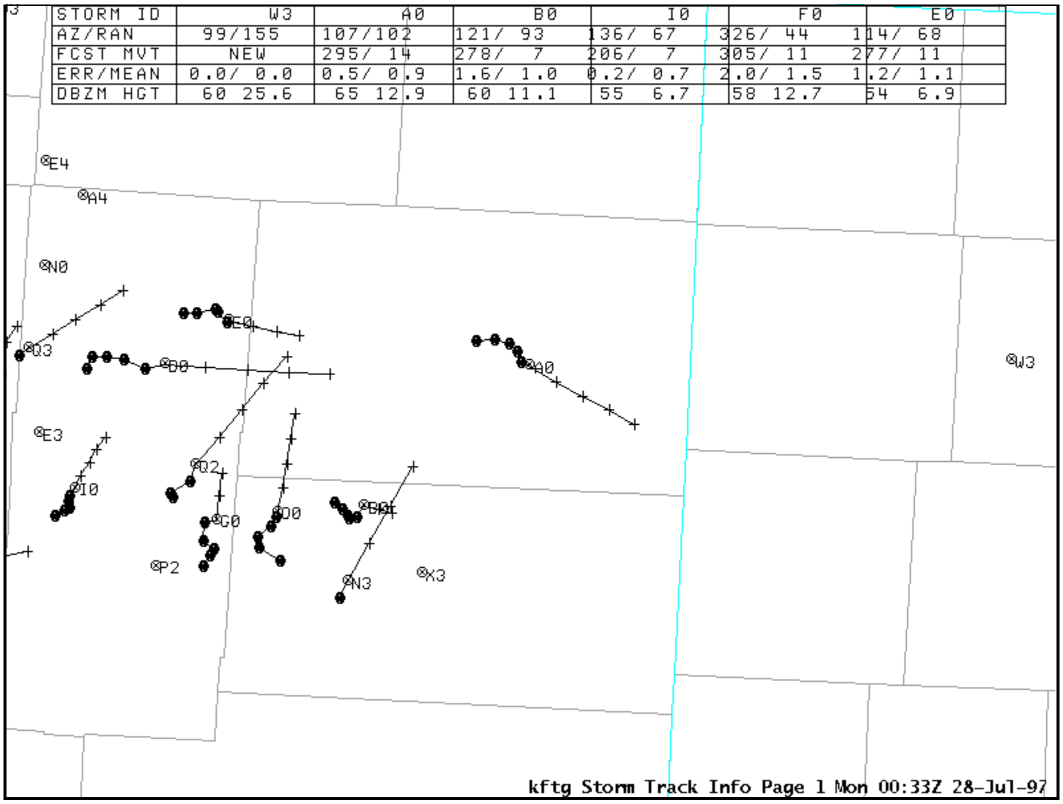


Figure 2-7. Storm Track Information (STI) Product.

STI product annotations:

- STI Attribute Table

Additional STI Product Characteristics

- RANGE: 248 nm (Effective Range 186 nm)

STI Attributes Table

The STI Attribute Table appears at the top of the STI product, and contains information on all identified cells. The STI Attribute Table lists the cells in order of Cell-based VIL from left to right from page 1 to the last page. On the first volume scan a cell is identified, the word “NEW” is placed on the line for forecast movement.

If 100 cells were identified, with only six cells per page, there would be 17 pages of attributes, although only 6 pages are currently viewable in AWIPS.

STORM/ID	W3	A0	B0	I0	F0	E0
AZ/RAN	99/155	107/102	121/ 93	136/ 67	326/ 44	114/ 68
FCST/MVT	NEW	295/ 14	278/ 7	206/ 7	305/ 11	277/ 11
ERR/MEAN	0.0/ 0.0	0.5/ 0.9	1.6/ 1.0	0.2/ 0.7	2.0/ 1.5	1.2/ 1.1
DBZM HGT	60 25.6	65 12.9	60 11.1	55 6.7	58 12.7	54 6.9

Figure 2-8. STI Attribute Table which appears at the top of the STI product.

Storm Track Information Alphanumeric Product

An STI Alphanumeric Product is received and stored in a text file along with every STI Graphic Product. The name of the text file is in the form: ***WSRSTIxxx***, where xxx is the radar ID. The STI Alphanumeric Product is displayable at the AWIPS text workstation, and contains information on the position and forecast of identified cells. The average speed and direction of all identified cells are shown near the top of the product. Cells are listed in order of Cell-based VIL from left to right. The azimuth and range of the current cell centroids along with the movement and forecast positions at 15, 30, 45, 60 minutes are listed.

STI Limitations

1. ***Errors may occur in the identification of cells and the calculation of cell attributes when cells are in close proximity.*** Recall from the previous discussion of Storm Cell Centroids that storm cells are defined by areas of highest reflectivity.
   - In Figure 2-9, a particularly high area of reflectivity (50 dBZ) occurred in Cell #1 at 0.5°, and only this area was saved as a component. Cell #2 has been identified with a Cell Base defined at the 1.5° slice even though a 40 dBZ echo exists at the 0.5° slice.
   - This type of problem will also affect other calculations such as Cell Top, Maximum Reflectivity Height, and Cell-based VIL. The operator should be skeptical of cell attributes anytime cells are in close proximity to each other.

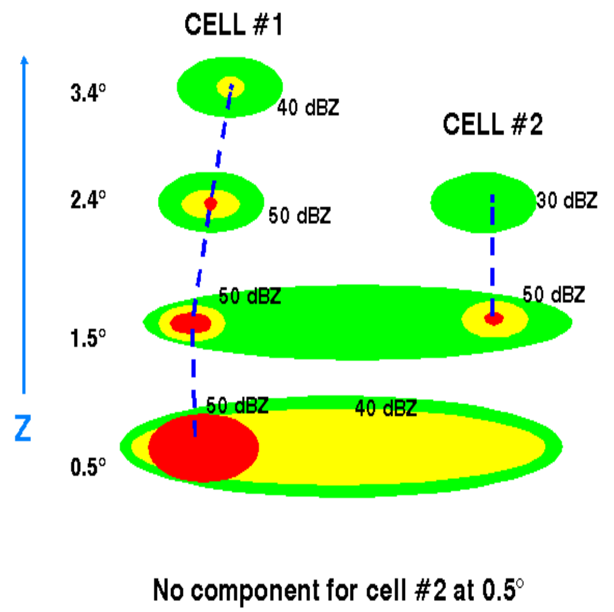


Figure 2-9. Storm Cell Centroids that storm cells are defined by areas of highest reflectivity.

- Cell attributes of supercells may also be inconsistent. The number of identified cells in a large supercell storm may vary from volume scan to volume scan. An example of this problem is seen on Figure 2-10, where cell-based VIL is compared to gridded VIL for a large supercell storm.

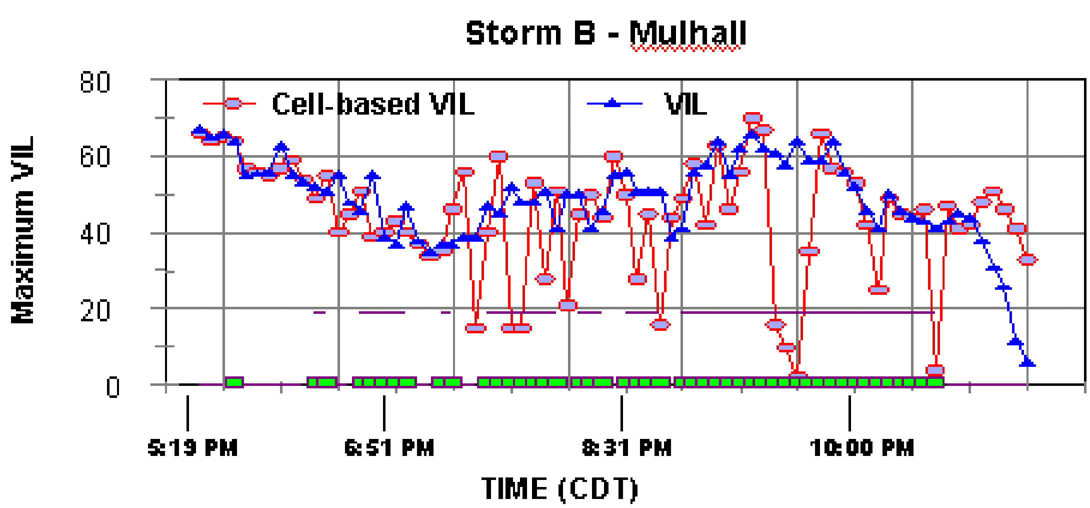


Figure 2-10. Comparison of cell-based VIL and gridded VIL for the "Mulhall" Storm that produced a long track tornado through the town of Mulhall, Oklahoma on May 3, 1999.

2. ***Large errors may occur in the attributes of cells close to the RDA, especially in VCP 21.*** Recall that there are large gaps between elevation angles at higher slices in VCP 21. Calculations of Cell-based VIL, Cell Base, Cell Top, Height of Maximum Reflectivity, etc. can all be adversely affected by what the radar is **not** sampling in these gaps.
3. ***Unrepresentative movements are possible due to propagational effects.*** Due to development or dissipation, the high reflectivity cores change location within an identified cell from one volume scan to the next, resulting in false representation of the movement of the cell.
4. ***Forecast positions of curving cells are displayed as a straight line.*** Since position forecasts are always in a straight line, the past tracks of a cell should be taken into account when using the position forecast of a curving cell.

STI Applications / Strengths

1. ***The product works best with well-defined widely separated cells***.

2. ***A large number of past tracks, and/or four forecast positions signifies a more reliable cell movement.*** Uneven spacing between past tracks, fewer than four forecast positions, and/or reidentification of cells indicate less reliable forecast positions.

3. ***The STI product is useful as an overlay on volume products, but not limited to volume products***.

4. ***Cell motion is used in Storm Relative Velocity products (SRM)*** covered in Lesson 4.

5. ***Cell attributes are critical inputs to the Hail Index product and SCAN.***

Radar Graphics Control

During active weather, the STI product could become extremely cluttered. Graphic controls are available at the AWIPS Workstations to allow the operator to reduce the clutter on the STI product. (See Fig. 2-11.)

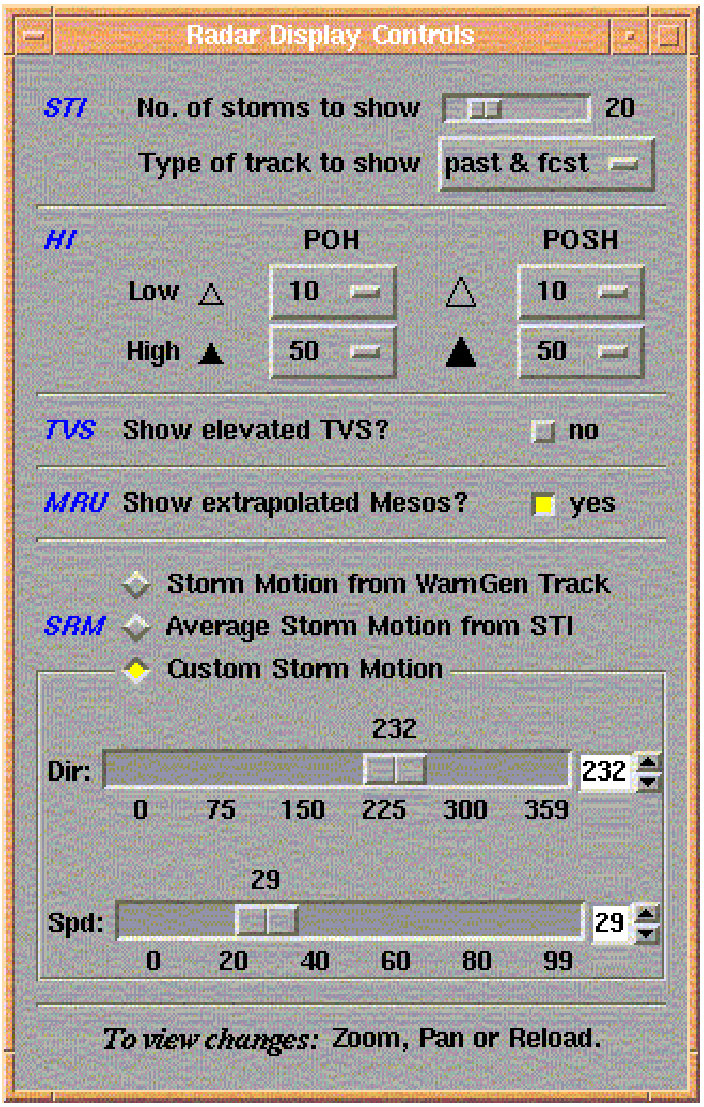


Figure 2-11. AWIPS Radar Display Controls for STI, HI, TVS, MRU, and 8-bit SRM products.

The number of identified cells to be displayed (up to 100), and whether or not to display the past positions and/or forecast positions is independently selectable at each AWIPS Workstation. If 30 cells are identified by the SCIT algorithm, and an operator selects only 10 to be displayed, only the top 10 ranked by Cell-based VIL would be displayed on the STI graphic product. Information on all 30 cells are available on pages 1 through 5 of the STI Attribute Table and also on the paired STI alphanumeric product. All other AWIPS Workstations will not be effected by this setting.

Hail Detection Algorithm (HDA)

Introduction

The Hail Detection Algorithm (HDA) has been designed to look for high reflectivities above the freezing level. Input of the 0°C and -20°C altitudes at the RPG HCI from a recent representative sounding can greatly improve algorithm output. The algorithm is designed to work independent of cell type, tilt, and overhang. The primary product produced by the algorithm is Hail Index (HI - Product ID #59) which can be useful in identifying cells that have the potential to produce hail.

The Hail Index product displays the following HDA estimates:

Probability Of Hail (POH) - identified as hail of any size, displayed in increments of 10%,

Probability Of Severe Hail (POSH) - identified as hail that is $\geq$ 3/4 inch, displayed in increments of 10%, and

Maximum Expected Hail Size (MEHS) - the estimate of the largest hail size identified anywhere in the cell, computed in increments of 1/4 inch.

If the cell is beyond the hail processing range of 124 nm, then the hail estimates are labeled as UNKNOWN in the Attribute Table.

Process

The Hail Detection Algorithm searches for high values of reflectivity above the freezing level (See Fig. 2-12 on page 52.). The reflectivities used are the maximum reflectivities of cell components above the freezing level. For the calculation of the POH, the location of the highest reflectivity of at least 45 dBZ above the freezing level is found. The greater the height above the freezing level, the greater the POH. In the calculation of POSH and MEHS, reflectivities greater than 40 dBZ which exist above the freezing level are used. In addition, a weighting factor is used, such that the greater the reflectivity above 40 dBZ, and the higher the altitude at which this reflectivity exists, the greater the weighting factor used. Reflectivities greater than 50 dBZ, and higher than the altitude of the -20°C isotherm, carry the most weight. **This illustrates the need for users to update the altitude of the 0°C and -20°C levels regularly**, especially when significant change to the atmosphere is experienced near the radar coverage area.

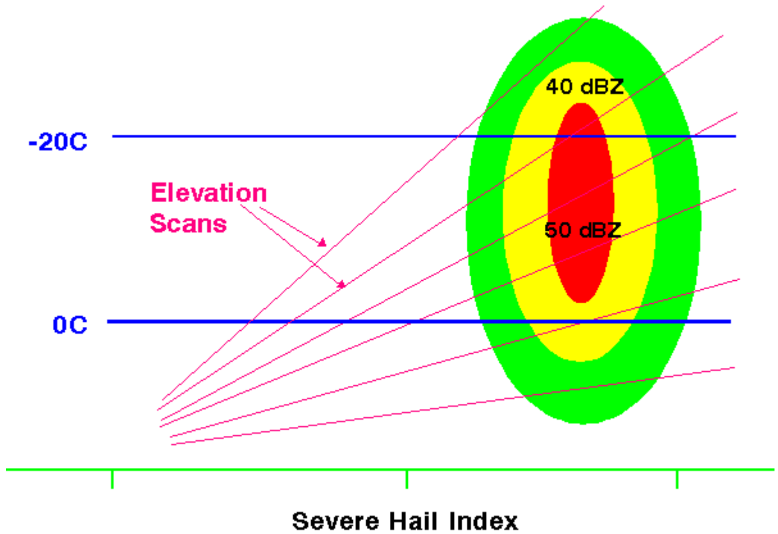


Figure 2-12. Hail Algorithm Process.

Hail Index Product

The Hail Index (HI - Product ID #59) graphic product uses symbols to depict the probability of hail. The POH will be represented with a small open or solid green triangle. For the triangle to appear the POH must exceed a **"Minimum Display Threshold"**(10% default). Whether the triangle is open or solid green depends on a **"Fill-in Threshold"** (50% default). The POSH is represented by a larger green triangle, again with the solid green triangle representing a "fill-in" threshold. The MEHS will be displayed in the center of the POSH symbol rounded to the nearest inch from 1 to 4. If a cell has hail identified that is less than 3/4 inch, then an asterisk (*) will be placed in the center of the POSH symbol.

Hail Index Attributes Table

The Hail Index Attributes Table will be available at the top of the product which lists the Cell ID, Azimuth and Range, POSH or POH, the MEHS (to the nearest 1/4 inch), and the last line in the table identifies the altitudes of the temperatures and the date/time at which the information was last

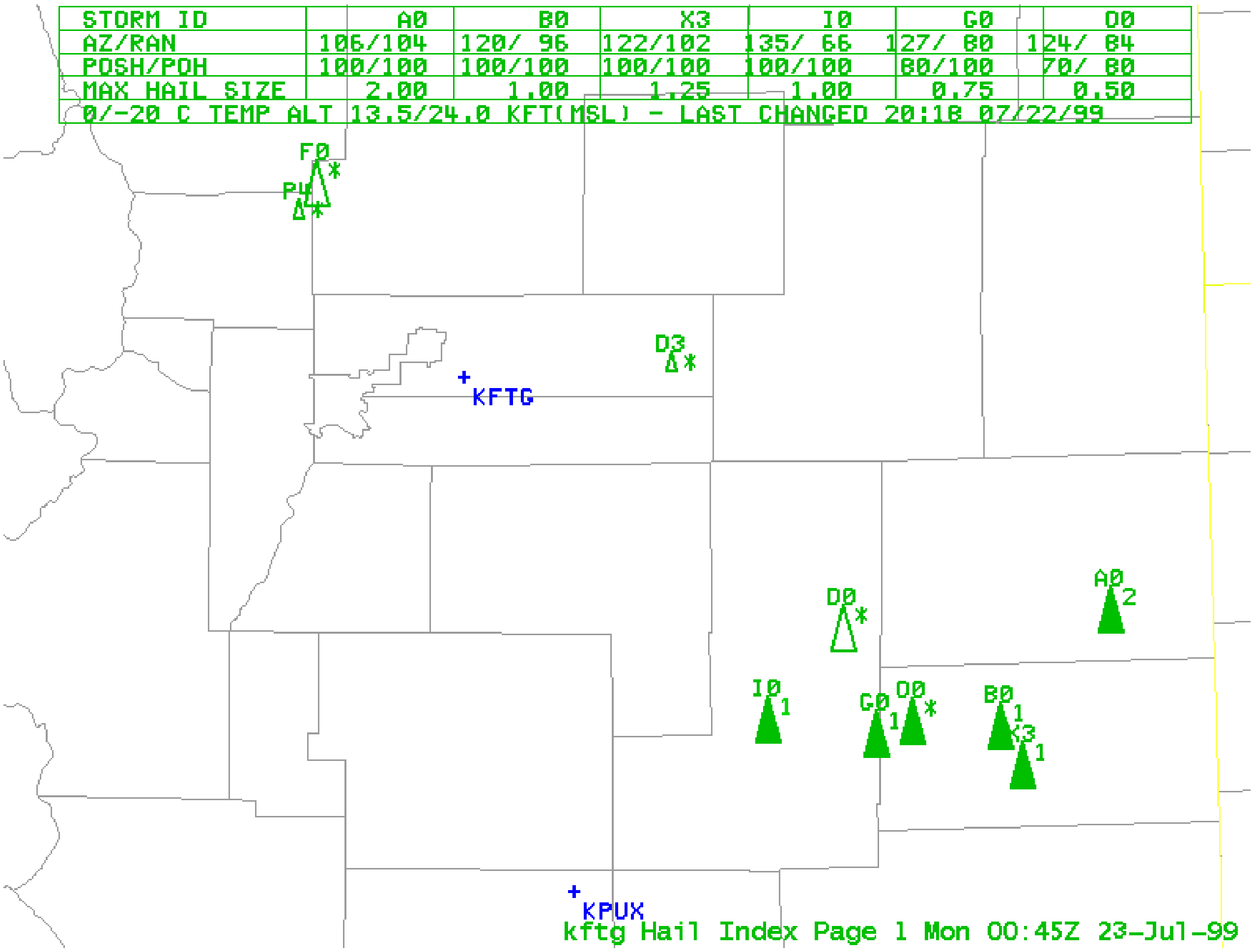


Figure 2-14. Hail Product

updated, (1/1/96 12Z is displayed if data has not been entered). Each page of the table can contain up to 6 cells. Cells are ordered first by POSH and then by POH. In addition, the parameters of POSH, POH, and MEHS will be displayed in the Composite Reflectivity Combined Attribute Table and the Hail Index alphanumeric product.

Icon Graphic Controls

Graphic controls are available at the AWIPS Workstations to allow the operator to adjust the Minimum and Fill-In Thresholds for the Hail Index Icons. These changes will not be viewable until the product is zoomed or reloaded. Changes made here will not effect other AWIPS workstations.

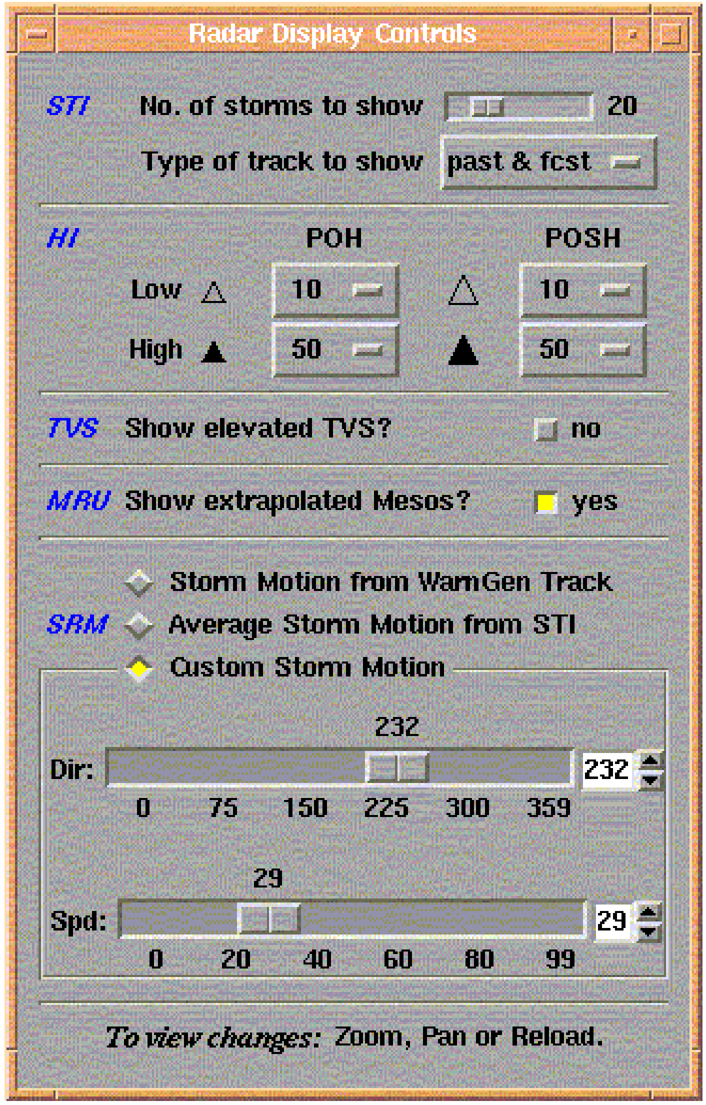


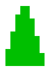
Figure 2-15. AWIPS Radar Display Controls for STI, HI, TVS, MRU, and 8-bit SRM products.

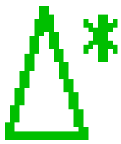
Hail Temperature Height Selection

The 0°C and -20°C heights used by the Hail Algorithm can be entered at the RPG HCI under the Environmental Data, to allow (under URC authority) the operator to input the most recent altitudes (see Fig. 2-16).

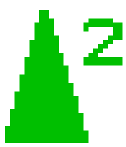
These values should be obtained from representative sounding information. If no recent nearby sounding is available, a forecast sounding or interpolation from surrounding soundings is recommended. **This should be done twice daily or as**


Minimum POH Display Threshold ≤ POH < Fill-in Threshold


POH ≥ Fill-in Threshold & POSH < Min. POSH Threshold



Minimum Display Threshold ≤ POSH < Fill-in Threshold



POSH ≥ Fill-in Threshold

Figure 2-13. Hail Symbols

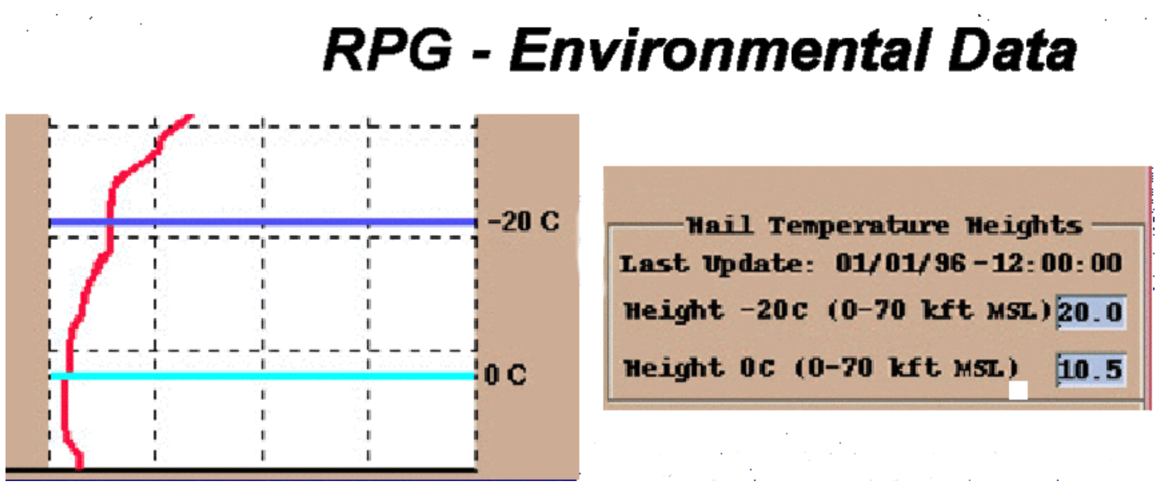


Figure 2-16. Hail Temperatures edit screens at the RPG HCI.

meteorological conditions warrant for the algorithm to provide accurate hail estimates.

HI Limitations

1. **The Hail Detection Algorithm needs as input, accurate and timely measurements of the MSL altitudes for the 0°C and -20°C lev-**

els. Failure to update this information will degrade the algorithm's performance.

2. **Values of POH, POSH, and MEHS will fluctuate at close ranges, especially in VCP 21**, due to gaps in coverage at higher elevation slices.
3. **The values for POH, POSH, and MEHS may fluctuate at longer ranges from the radar due to the limited number of slices through the cell.**
4. The maximum hail processing range is 124 nm. **For cells beyond 124 nm, hail will be identified as UNKNOWN**.
5. **POSH and MEHS tend to overestimate the chances and size of hail in weak wind and tropical environments and mountainous locations**. The accuracy of the hail estimates partially depends upon the accuracy of cell (component) information.
   - MEHS is an estimation of the largest hail in the cell, and often times, most of the hail from a cell is smaller.
   - The operator has to keep in mind that the MEHS should only be used as a guide. Storm spotters and other operational means should be integrated into the warning decision.

HI Application / Strength

1. The Hail Detection Algorithm has shown a very high probability of detection in cells that contain severe hail, especially greater than one inch diameter hail. **A POSH of 50% or greater has shown skill as a warning threshold.**

Interim Summary

Storm Track Information (STI) Product

1. Errors occur in cell identification and tracking when cells are in close proximity.
2. Cell identification and tracking work best when storms are separated and little development or dissipation is occurring.
3. A large number of past tracks and/or four forecast positions are indications of reliable tracking.
4. Cell attributes are unreliable in VCP 21 within 60 nm of the RDA.

Hail Index Product

1. Hail Index (HI) displays three values: Probability of Severe Hail (POSH), Probability of Hail (POH), and Maximum Expected Hail Size (MEHS) for identified cells.
2. Hail attributes are calculated by comparing SCIT defined component maximum reflectivity heights to operator input heights of the 0 and minus 20 degree heights.

Lesson 3: Reflectivity Based Products

Objectives

Upon completion of this lesson, you will be able to identify specific characteristics, limitations, and applications (strengths) of the following products:

1. Vertically Integrated Liquid (VIL)
2. Digital (or High Resolution) VIL (DVL)
3. Composite Reflectivity (CZ)
4. Layer Composite Reflectivity Maximum (LRM)
5. User Selectable Layer Reflectivity (ULR)
6. Enhanced Echo Tops (EET)

Vertically Integrated Liquid (VIL)

VIL values represent reflectivity data converted into equivalent liquid water values. What you are really viewing is integrated reflectivity, <u>not</u> a storm's precipitable water content, as was the original intent.

Process

The VIL equation is:

$$M = 3.44 \times 10^{-3} Z^{4/7}$$

where M = liquid water content (g m-3)

Z = radar reflectivity (mm6 m-3)

The values are derived for each 2.2 x 2.2 nm grid box; then vertically integrated. VIL values are output in units of mass per area (kg m^{-2}).

The algorithm ***assumes reflectivity returns are from liquid water,*** only using reflectivities greater than 18 dBZ.

Reflectivity returns from hail are non-linear & would result in unrealistically high values, so all

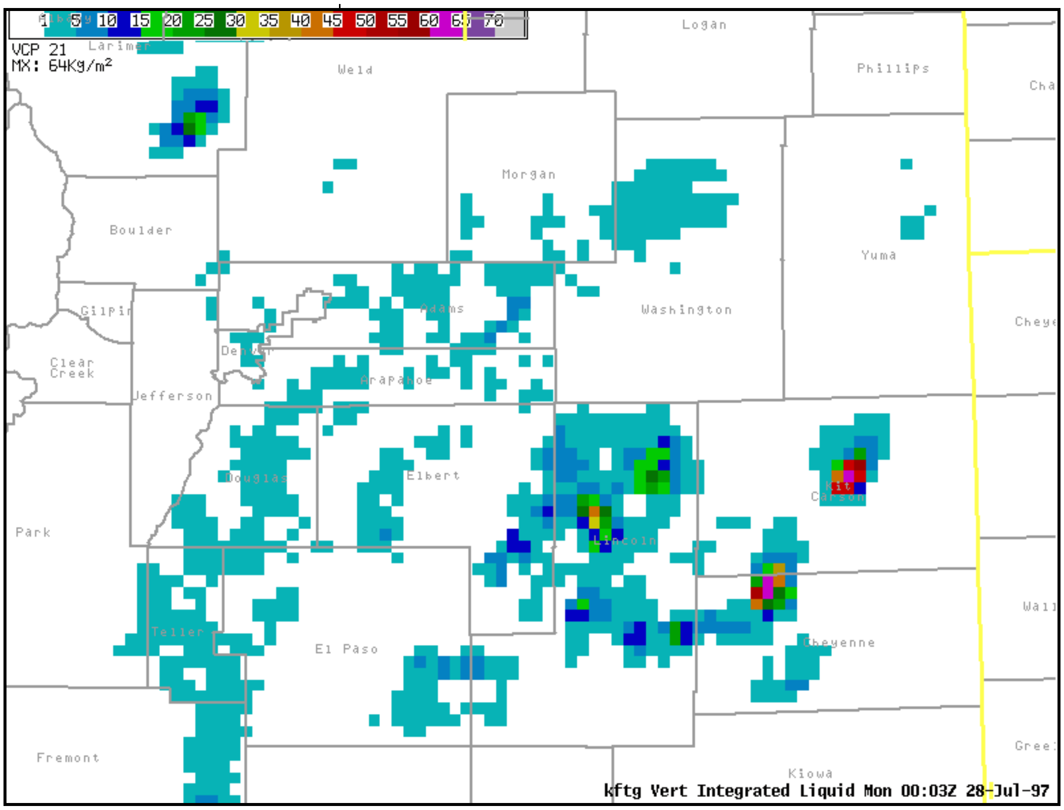


Figure 3-1. Vertically Integrated Liquid (VIL) product

reflectivities greater than 56 dBZ are truncated to 56 dBZ.

VIL Product Characteristics

See Figure 3-1 for an example of the VIL product.

VIL product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Vert Integrated Liquid
- DATE: Day of week, time, and date in UTC

VIL product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum value in kg/m^2. The location of this value is unknown.

Additional VIL product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: Data level values range from 1 kg/m^2 to 70 kg/m^2.

VIL Limitations

1. VIL values are biased by drop size.

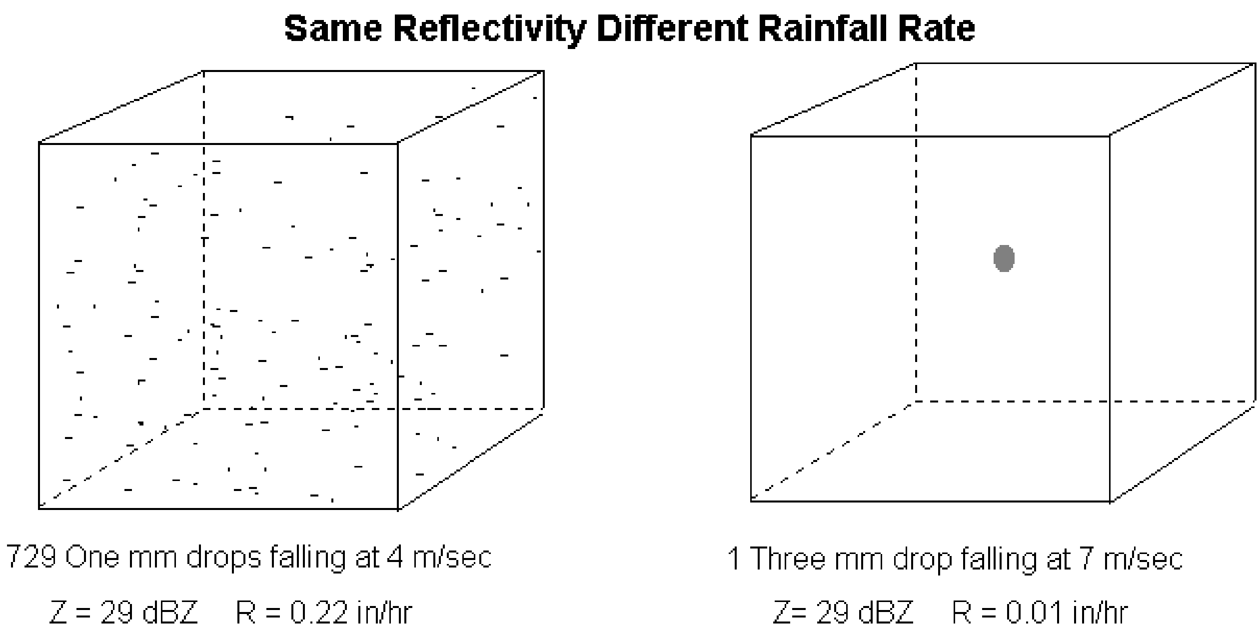


Figure 3-2. Effect of drop size on target reflectivity

2. Grid VIL values will differ from Cell-Based VIL values.

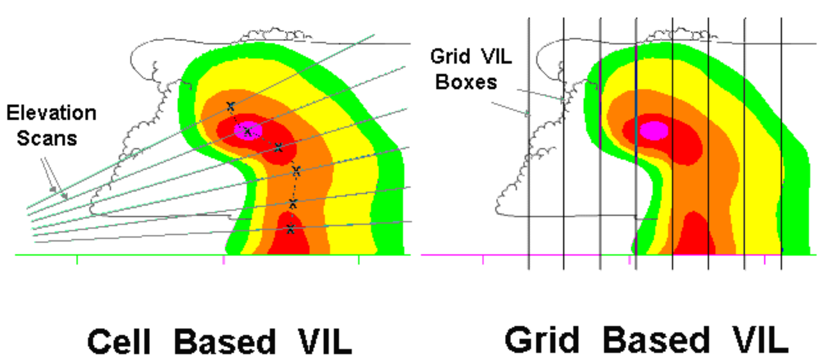


Figure 3-3. Cell-based vs. Grid-based VIL.

3. Values for warnings may change daily and across the *warning area.* Values are air mass dependent.

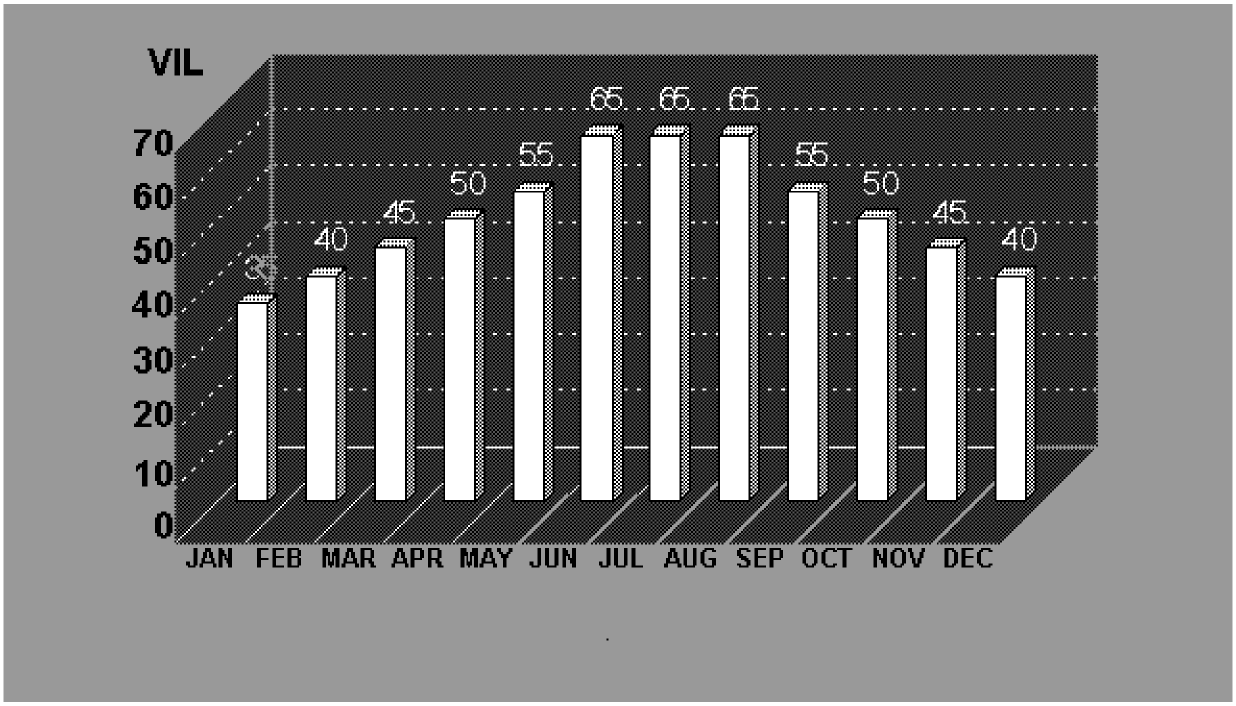


Figure 3-4. Estimated VIL values needed for large hail in Oklahoma.

4. **Values within 20 nm of radar are underestimated.** This is due to the cone of silence.
5. **VIL values for a strongly tilted or a fast moving storm will be *lower* than if the storm was vertical or moving slower.** The upper portion of the storm may extend into another grid box.
6. **May be contaminated by non-precipitation echoes.**
7. **More VIL fluctuation with VCPs 21 and 121 than VCPs 11 or 12.** There are fewer gaps in VCPs 11 and 12. This is mainly within 60 nm of the radar. This study is of observed VIL values.(see Fig. 3-5))
8. **Values at distant ranges (≥ 110 nm) are *unreliable.*** The reflectivity value at 0.5° is integrated down to the ground. At distant ranges the beam may be cutting through the highly reflective hail cores in the mid levels of a storm producing an overestimation of VIL, or overshooting the convection and underestimating VIL.

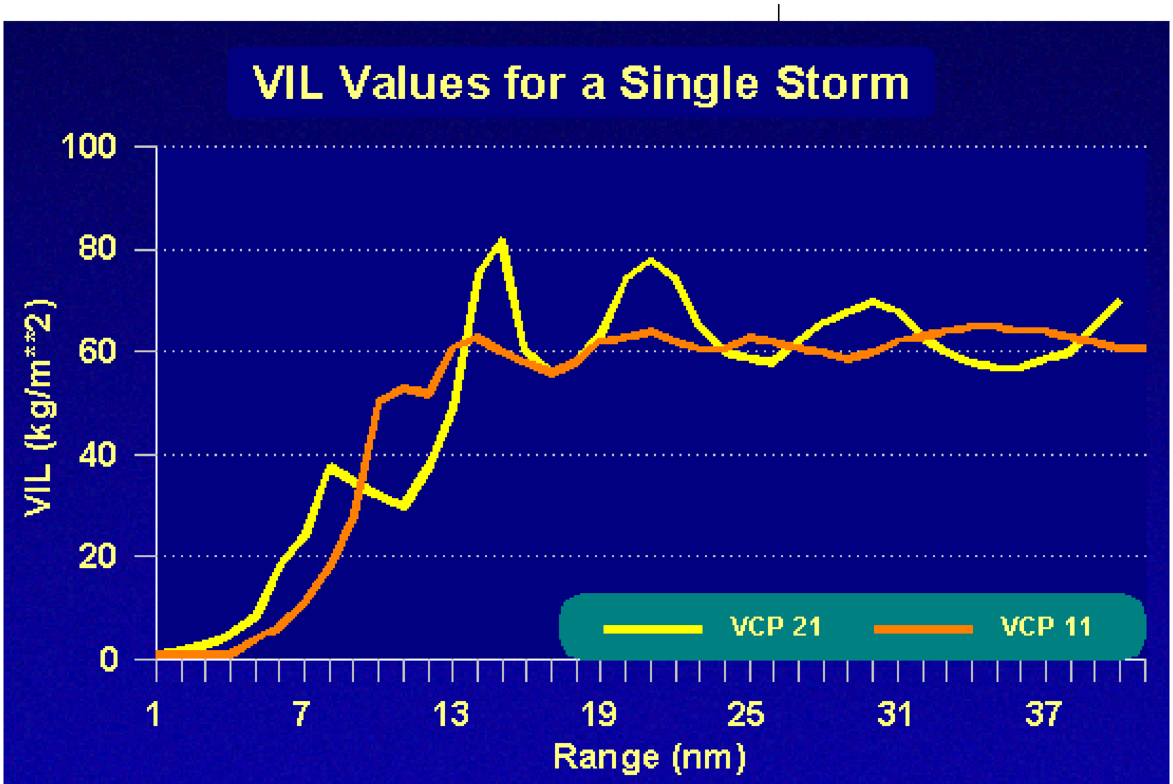


Figure 3-5. This study is from measurements of a single storm using two different volume coverage patterns. The results of the study show that a storm moving toward or away from the RDA will have more fluctuation in VIL values in VCP 21 than in VCP 11. This is due to the fact that there are more gaps in VCP 21 than in VCP 11. This effect is most noticeable within 60 nm of the RDA.

VIL Applications / Strengths

1. **Locate the most significant storms.**

   High VIL values correspond to deep areas of high reflectivity indicative of strong updrafts. VIL Density (VIL divided by Echo Tops - see Amburn and Wolf (1997)[1]) has also shown some skill indicating significant storms. Limitations of VIL previously listed (e.g., storm tilt and fast moving storms) and Echo Tops (later in this lesson) should always be considered when using these values.

2. **Useful for distinguishing storms with large hail once threshold values have been established.**

   Establishing a VIL of the Day using climatological data and/or sounding data (e.g., see Paxton and Shepherd (1993)[2]) can be of some limited use for initial development, but better skill can be achieved by real-time comparison between VIL values and spotter reports. As with all algorithm output, VIL alone should never be used as a warning criteria.

3. **Persistent high VIL values associated with supercells.** The exception is mini-supercell thunderstorms or LP Supercells (see Burgess et al (1995)[3]).

4. **Rapid decrease in VIL values may signify the onset of wind damage.**

   Use caution with this technique. It is important to know which VCP is being used because of gaps in the coverage in VCP 21. For more information see An Overview of Operational Forecasting for Wet Microbursts by William P. Roeder (45th Weather Squadron, USAF Cape Canaveral, FL) on the WDTB Web page (http://www.wdtb.noaa.gov/workshop/psdp/Roeder/index.htm).

Digital (High Resolution or 8-bit) VIL (DVL)

The Digital VIL product is **not** a replacement for the existing gridded VIL product. Although it uses a the same equation as VIL to convert reflectivity to kg/m^2, the finer data resolution (1° by 1 km polar format), and lack of truncation has a substantial impact on the value. There have been instances where a value of 40 to 45 kg/m^2 on the VIL product equated to a value of 80 kg/m^2 on the DVL prod-

[1]Amburn, Steven A., Peter L. Wolf, 1997: **VIL Density as a Hail Indicator.** *Weather and Forecasting*: Vol. 12, No. 3, pp. 473—478.

[2]Paxton, C. H., and J. M. Shepherd, 1993: Radar diagnostic parameters as indicators of severe weather in central Florida. *NOAA Tech. Memo. NWS-SR 149,* 12 pp.

3Burgess, D. W., R. R. Lee, S. S. Parker, D. L. Floyd, and D. L. Andra Jr., 1995:A study of mini supercells observed by WSR-88D radars. Preprints, *27th Conf. on Radar Meteorology,* Vail, CO., Amer. Meteor. Soc., 4—6.

uct. Any empirical study using VIL (e.g., VIL Density, VIL of the Day, etc.) should **not** be used with the DVL product.

Process

The same equation is used to convert reflectivity to liquid water content:

$$M = 3.44 \times 10^{-3} Z^{4/7}$$

where M = liquid water content (g m-3)

Z = radar reflectivity (mm6 m-3)

The values are derived from each 1 km (0.54nm) x 1 degree, and then vertically integrated. DVL values are output in kg/m^2, and displayed in 256 data levels from 0 to 80 kg/m^2 out to a range of 460 km (248 nm).

DVL uses **all** reflectivity data available (recall VIL uses only reflectivities above 18 dBZ). There is currently (RPG B5) **no truncation** of higher reflectivities (recall VIL truncates reflectivities above 56 dBZ).

DVL Product Characteristics

See Fig. 3-6 for an example of the VIL product.

DVL product legend description:

- RPG ID: kxxx
- PRODUCT NAME: 8-bit VIL
- DATE: Day of week, time, and date in UTC

DVL product annotations

- VCP: 11, 12, 21, 121, 31 or 32

- MX: This is the maximum value in kg/m^2. The location of this value is unknown.

Additional DVL product characteristics

- RANGE: 248 nm
- RESOLUTION: 0.54nm x 1 degree

DATA LEVELS: 256 Data level values range from 0 kg/m^2 to 80 kg/m^2.

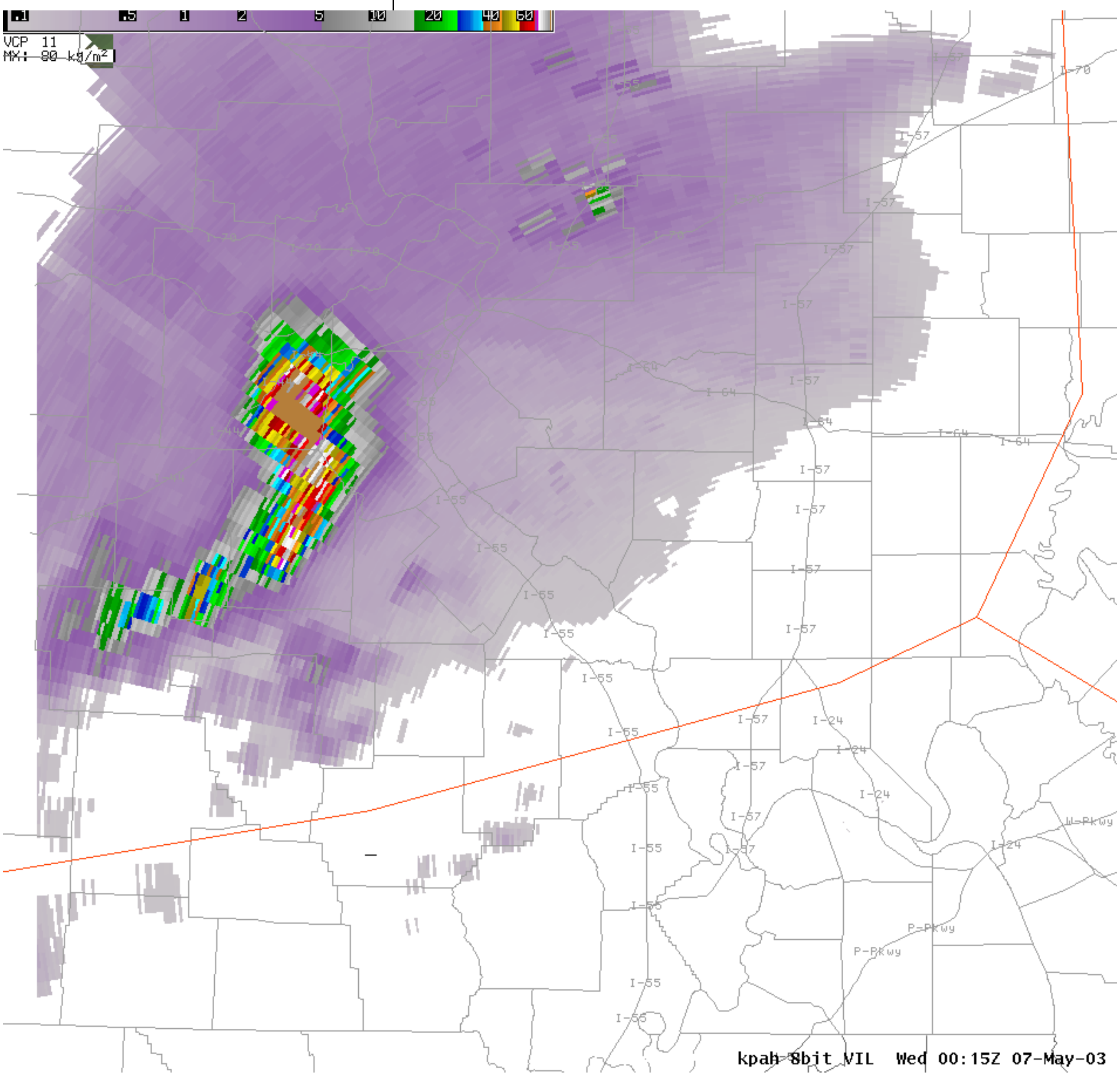


Figure 3-6. Digital VIL (DVL) product in AWIPS.

DVL Limitations

1. Higher resolution and lack of truncation produces different values when compared to VIL.
   - VIL research findings (VIL Density, VIL of the Day, etc.) are invalid for DVL.
2. Fast moving or highly tilted storms will produce lower DVL values than if the same storm was vertical or slow moving.
   - This has a greater impact on DVL than VIL due to the smaller bin size of DVL (1 km x 1 degree) vs. VIL (4 km x 4 km).
3. 80 kg/m^2 (maximum displayed DVL value in AWIPS) is commonly reached due to lack of truncation of high reflectivities.
   - Since many storms have DVL values of >80 kg/m^2, it is more difficult to isolate the most significant storms.

DVL Applications / Strengths

1. Displays low reflectivity features (snow bands, gust fronts, smoke plumes, etc.)
   - Use of low reflectivities (<18 dBZ) in calculations, and display of VIL less than 1 kg/m^2 allows display of low reflectivity features.
2. Ground clutter has less impact on DVL than other volume products (e.g., Composite Reflectivity)
   - The FAA plans to use this product instead of Composite Reflectivity for this reason. Ground clutter has high reflectivities, but they are shallow. The vertical integration lowers the impacts of the highly reflective ground clutter.

Reflectivity Cross Section (RCS)

The WSR-88D can generate a cross-section between any two points within a 124 NM range as long as the points are no greater than 124 nm apart.

Process

The cross section product is a volume product created by:

1. ***Linking all elevation scans*** using 0.54 nm base data.
2. ***Interpolating vertically between elevation angles*** where no data are collected (vertical resolution 0.27nm).
3. ***No extrapolation is performed from highest or lowest elevation angle.*** It uses beam center point height.

Cross section products are not recommended for RPS List since endpoints change constantly.

Product Request

Using Interactive Lines, the user places a line through a storm of interest. Lines are referenced by the letters assigned to the endpoints, e.g. A & A', B & B', etc. The RCS requires a full volume scan of data, it is generated using data from the last completed volume scan. See Figure 3-7 for an example of the request screen for the RCS product.

Product Interpretation

The user selects 2 points (AZRANS) which can be up to 124 nm apart, but within 124 nm of the RDA. On the cross section product, ENDPT1 is always on the left side, ENDPT2 is on the right. It doesn't matter in which order they are picked. ENDPT1 is defined as the western most point picked, unless along the same longitude, then ENDPT1 is the northern point. The RCS is created using data from the last completed volume scan.

Product dimensions

- Height on Z axis is at 10,000 ft intervals (Above Radar Level (ARL)), which cannot be changed.
- Range on X/Y axis depends upon length of cross section. Endpoint AZRAN (Azimuth/Range) are listed in the annotations area and on the bottom of the cross section.

See Figure 3-8 for an example of the RCS product.

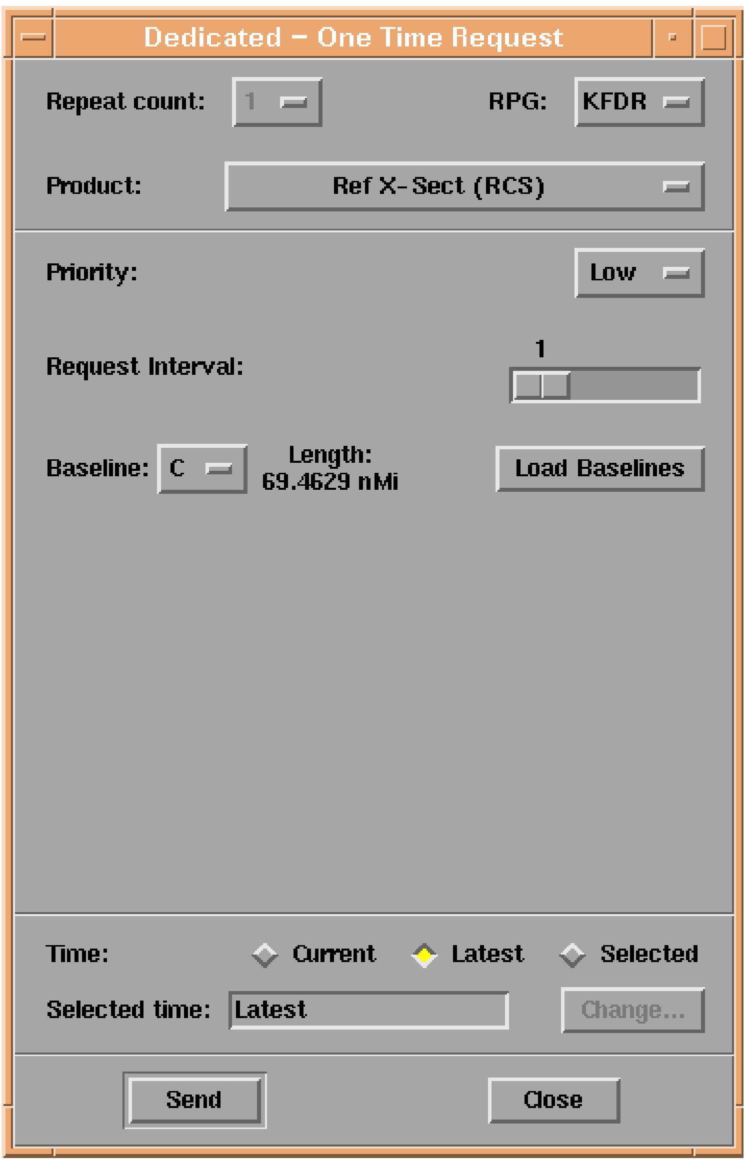


Figure 3-7. RCS product request screen

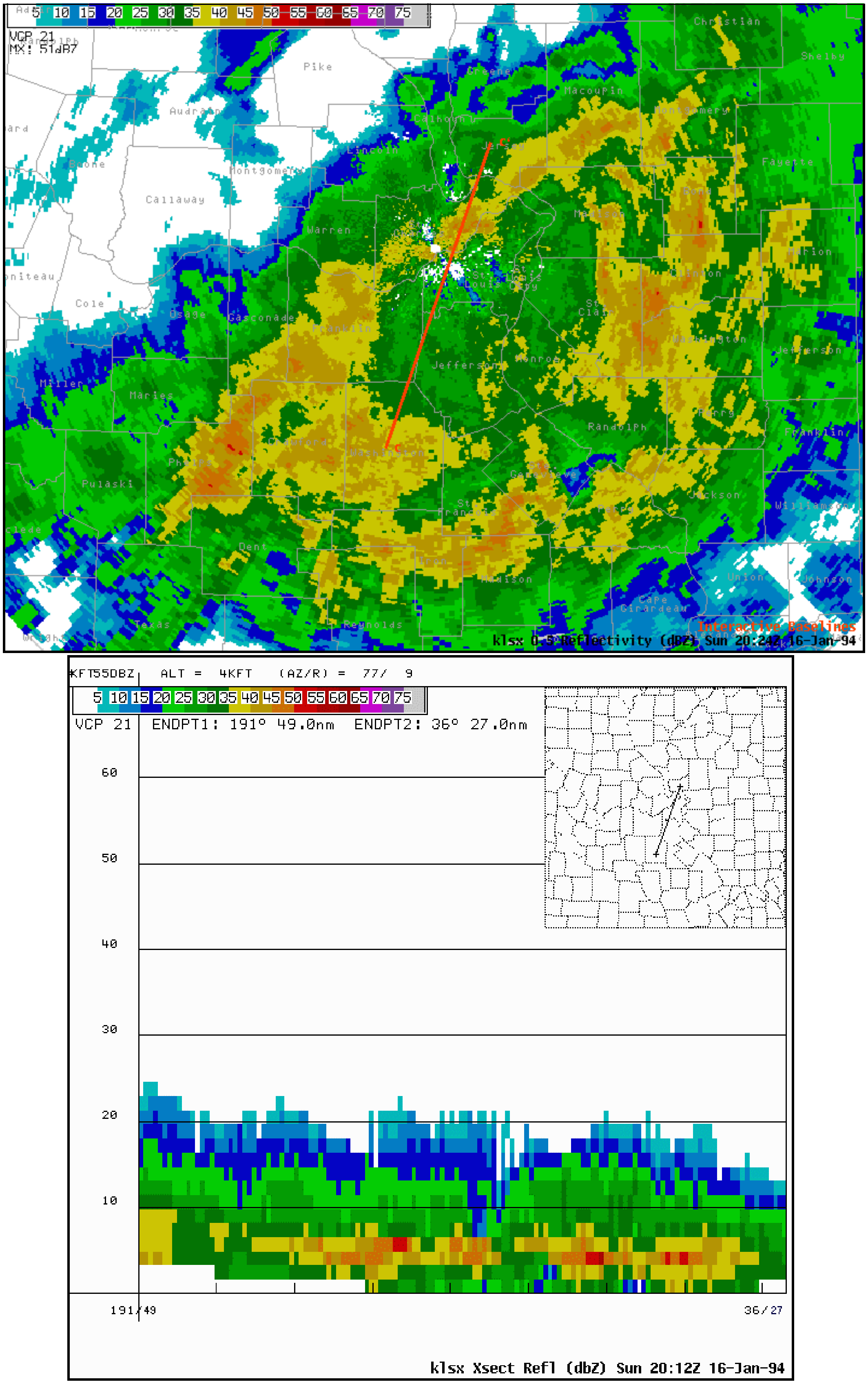


Figure 3-8. Top: Base Reflectivity overlaid with the interactive line used to generate the cross section. Bottom: Matching Reflectivity Cross Section

Reflectivity Cross Section (RCS) Product Characteristics

RCS product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Xsect Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

RCS product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- ENDPT1: This is the AZRAN of the western-most point.
- ENDPT2: This is the AZRAN of the eastern-most point.
- MAX (dBZ), ALT (Kft), (AZ/R): Max reflectivity in the cross section, its altitude and AZRAN.

Reflectivity Cross Section Limitations

1. ***Cross section placement may hamper evaluation of storm structure.***
2. ***Echo tops and bases are truncated,*** no vertical extrapolation on the highest or lowest elevation angles.
3. ***Height vs. range exaggeration.*** The vertical extent of the product is 70,000 ft (~11.5 nm), while maximum range is 124 nm.
4. ***Small features may be enlarged or missed due to interpolation.***
5. ***Presentation of product dependent upon VCP. More coarse with VCPs 21 and 121 than VCPs 11 and 12.*** Due to more gaps within 60 nm of the radar in VCP 21.
6. ***Fast moving storms may appear to be strongly tilted.*** Because of the time needed to complete a volume scan.

Reflectivity Cross Section Applications / Strengths

1. ***Detect the vertical extent of clouds/insects/smoke plumes***.
2. ***Verify existence and location of a bright band.***
3. ***Estimate height of higher dBZ's.*** Placement is critical when attempting to estimate dBZ heights.
4. ***Evaluate storm structure features.*** Again, placement is critical in order to see features such as BWERs, WERs, storm tilt, and low echo centroids.
5. ***Estimate echo tops.*** This product will display reflectivities down to 5 dBZ in precipitation mode.
6. ***Monitor the formation/dissipation of precipitation events.***

Interim Summary

Vertically Integrated Liquid (VIL)

1. Knowledge of the meteorological environment is necessary to use product effectively.
2. Alerts operator to most significant storms.
3. Effective for detecting storms with 3/4 inch or larger hail.
4. Critical threshold values must be established for differing climatological regions.

Digital VIL (DVL)

1. Different product than VIL with different applications.
2. No truncation of high reflectivities produces a lot of storms with 80 kg/m^2.
3. Displays low reflectivity features such as boundaries, snow bands, smoke plumes, etc.

Reflectivity Cross Section (RCS)

1. Placement is critical to interpretation.
2. Determine storm structure features such as updraft flank, tilt, storm top, WERs, BWERs, and the vertical extent of higher reflectivities.
3. Cross sections must be within 124 nm of radar with a maximum length of 124 nm.

Composite Reflectivity (CZ)

The Composite Reflectivity product displays the highest reflectivity for each grid box for all elevation angles.

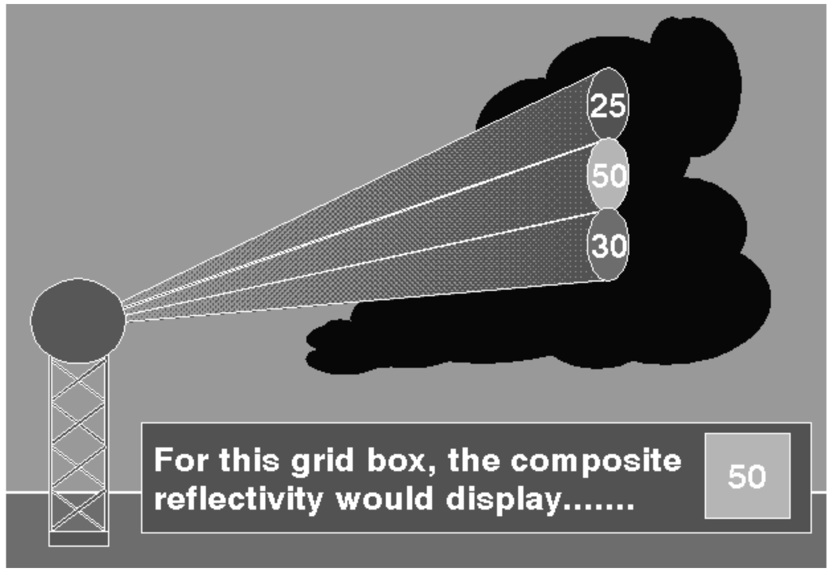


Figure 3-9. Composite Reflectivity

Resolution

- 1 km x 1 km (.54 x .54 nm) range 124 nm
- 4 km x 4 km (2.2 x 2.2 nm) range 248 nm

Note: There is *no 2 km (*1.1 nm) resolution product

Combined Attributes Table

The Combined Attributes Table is only available on the Composite Reflectivity (See Figure 3-10). The table contains output from the following algorithms:

1. SCIT

2. HDA

3. TVS

4. MESO

Some outside users are only able to access TVS and MESO detections using the Combined

STORM/ID	AZ/RAN	TVS	MESO	POSH/POH/MX SIZE	VIL	DBZM HT	TOP	FCST MVMT
SO	357/ 62	NO	YES	70/100/ 1.25	46	59 18.5	32.7	238/ 29
AO	181/ 90	NO	NO	100/100/ 2.50	62	66 20.0	37.7	257/ 33
C3	160/107	NO	NO	80/100/ 1.25	53	61 13.7	35.2	234/ 39
F3	326/ 16	NO	NO	70/100/ 1.25	37	62 15.8	>34.0	NEW

Figure 3-10. Combined Attributes Table which appears at the top of the Composite Reflectivity product.

Attributes Table. This can lead to confusion since the table only includes azimuth and range to the **storm cell centroid**, not the TVS or MESO location.

The Combined Attributes Table includes:

- **STM ID** - Cell ID letter/number
- **AZ/RAN** - Azimuth and Range of **cell centroid**
- **TVS** - Yes if TVS is present or No
- **MESO** - Yes or no for MESO only. It will always be no for 3-D Correlated Shear, or Uncorrelated Shear.
- **POSH / POH / MX SIZE** - Probability of Severe Hail / Probability of Hail / Max Hail Size
- **VIL** - Cell Based VIL
- **DBZM HT** - Maximum reflectivity (dBZ) and height of maximum reflectivity (Kft)
- **TOP** - Height of upper most component (Kft)
- **FCST MVMT** - Forecast movement (deg./ kts)

Order of storms

1. TVS or ETVS
2. Mesocyclone, 3DC Shear, Uncorrelated Shear
3. Probability of Severe Hail (POSH)
4. Probability of Hail (POH)
5. Cell based VIL

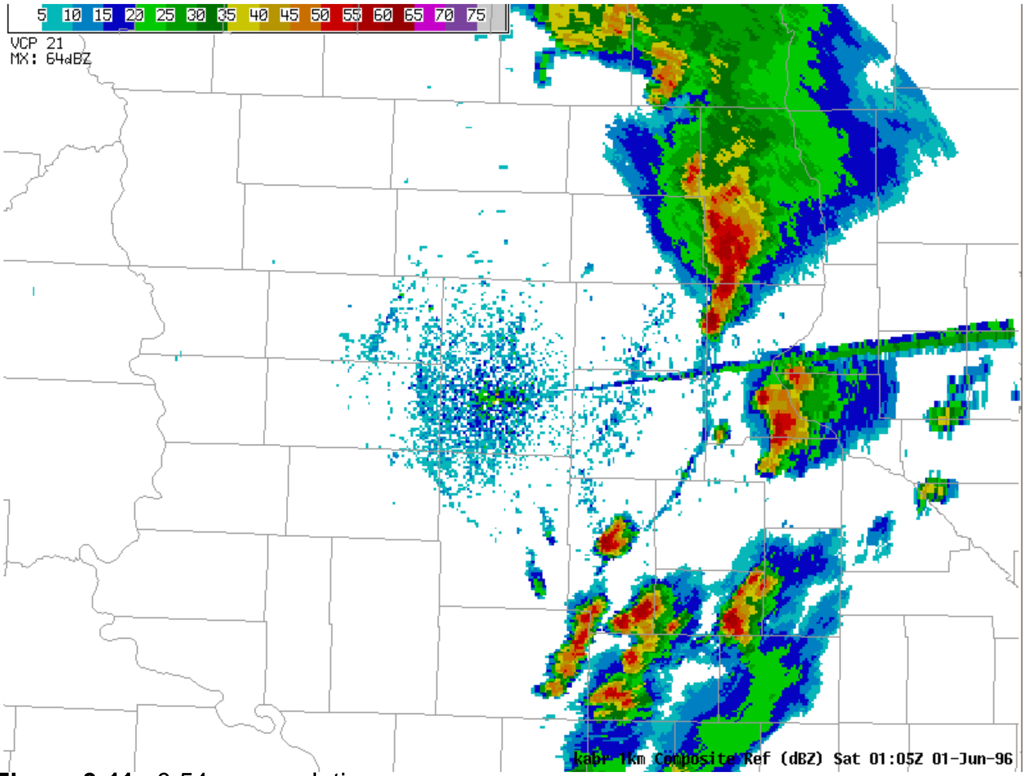


Figure 3-11. 0.54 nm resolution.

Note: Cells with unknown POSH or POH (i.e., cells beyond 124nm), yet high cell based VIL, may end up at the bottom of the Combined Attributes Table.

Composite Reflectivity (CZ) Product Characteristics

See Figure 3-11, 3-12, and 3-13 for examples of the CZ product.

CZ product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Composite Ref
- UNITS: dBZ
- DATE: Day of week, time and date in UTC

CZ product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This

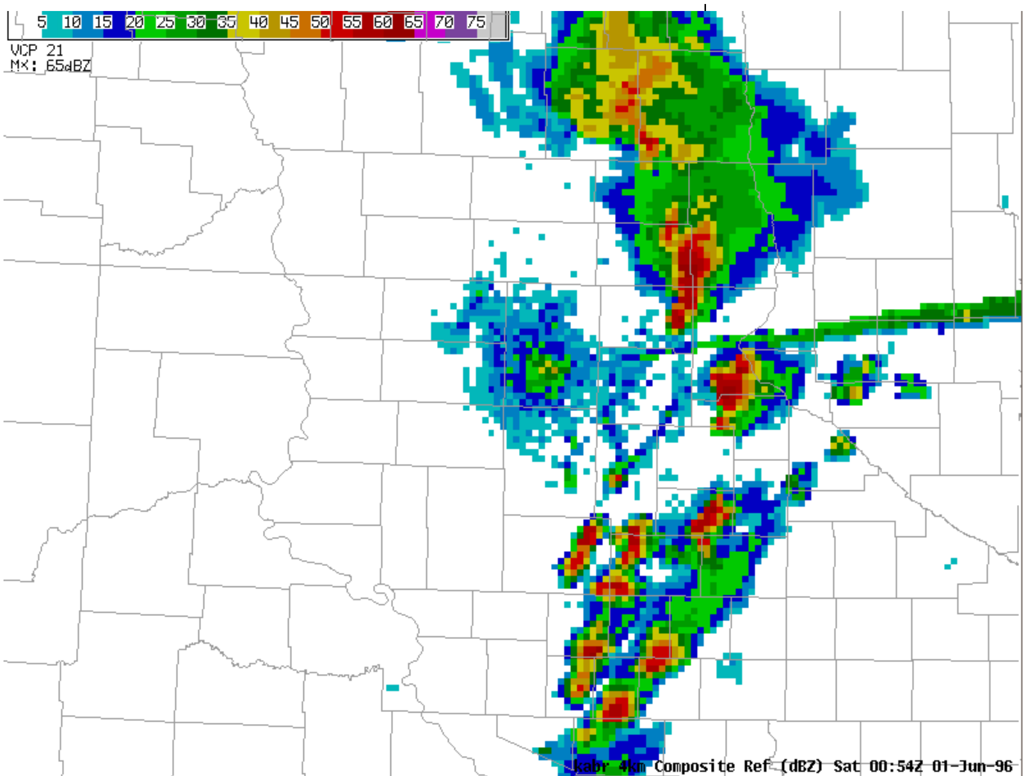


Figure 3-12. 2.2 nm resolution

value will not change when zoomed in on a feature, as it is the maximum value for the entire product.

Additional CZ product characteristics

- RANGE: 124 or 248 nm
- RESOLUTION: .54 or 2.2 nm, respectively
- DATA LEVELS: 16 data levels - values range from 5 to 75 dBZ

Composite Reflectivity Limitations

1. **Low level reflectivity signatures are obscured.**
2. **Height of reflectivity is unknown.**
3. **Echo aloft can't be discriminated from precipitation reaching the surface.**
4. **Non-precipitation echoes may contaminate product.**

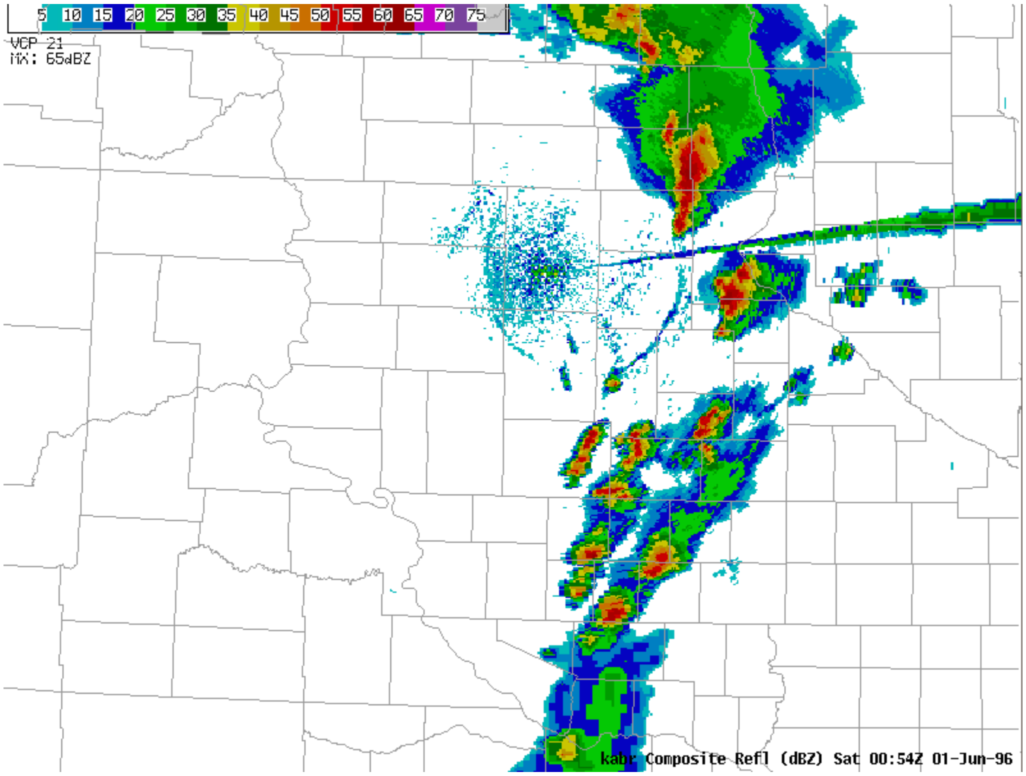


Figure 3-13. Composite Reflectivity (CZ) product showing both resolutions.

Composite Reflectivity Applications / Strengths

1. **Reveals highest reflectivity in all echoes.**
2. **Determine storm structure features & intensity trends in storms.** (When compared with base products).
3. **Generate cross sections through maximum reflectivity knowing the inflow side of storm.** The operator will have more predictable results with a .54 nm product.
4. **The Combined Attributes Table is available.**

Layer Composite Reflectivity Maximum (LRM)

Displays the highest reflectivity value of all elevation angles for each 2.2 x 2.2 nm grid box in a layer.

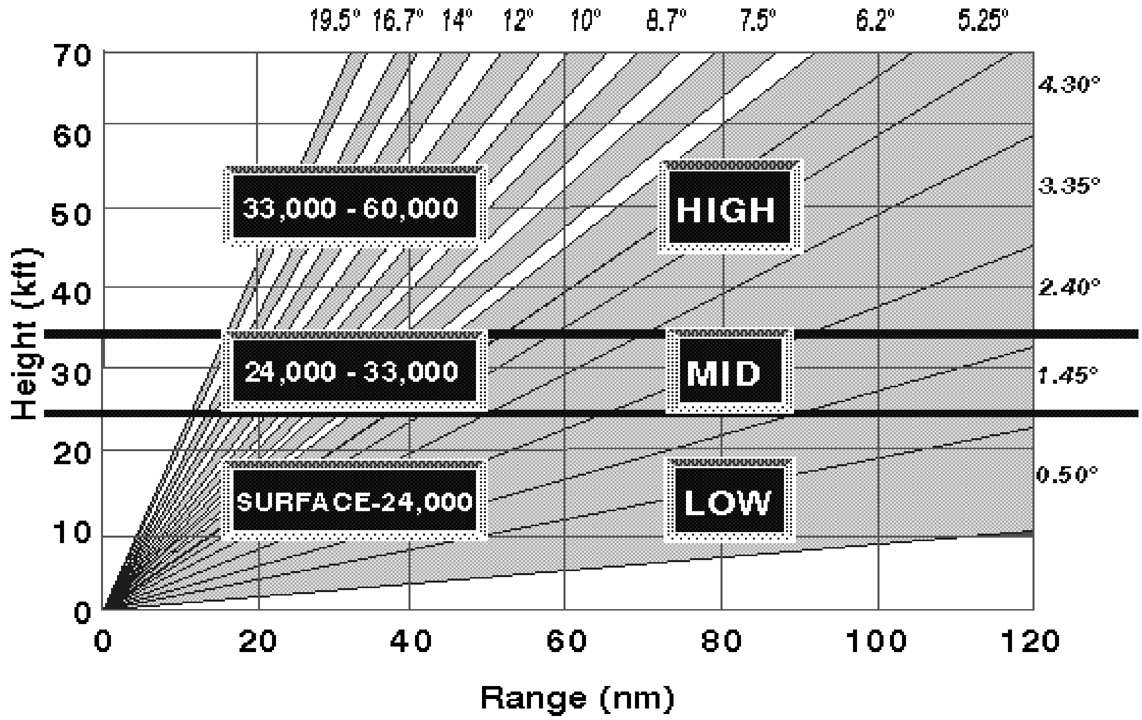


Figure 3-14. Layer Composite Reflectivity Default Layers (VCP 11)

Three layers

- **Low** (Layer 1) **-** Just above radar level to 24,000 ft
- **Mid** (Layer 2) **-** 24,000 ft to 33,000 ft
- **High** (Layer 3) **-** 33,000 ft to 60,000 ft

No changes can be made to alter the depths of these products. If different layers are desired use the User Selectable Layer Reflectivity (ULR) product described next.

Originally developed for CWSU/FAA use.

Desired product layers (L,M,H) can be specified on the RPS list or one time request.

Resolution 2.2 x 2.2 nm; Coverage **248 x 248 nm**.

Available with **8** data levels only

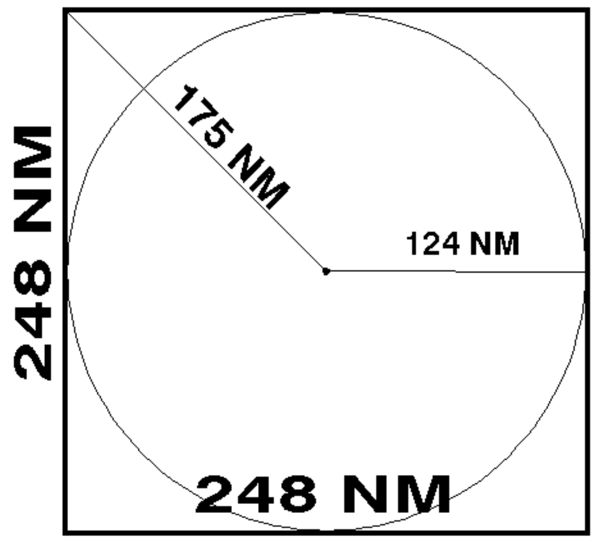


Figure 3-15. LRM/LRA Product size.

LRM Product Characteristics

See Figure 3-16 for an example of the LRM product.

LRM product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Layer 1 (2 or 3) Max Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

LRM product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- BOT: Bottom of the layer in kft
- TOP: Top of the layer in kft
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the maximum value for the entire product.

Additional LRM product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: Data level values are fixed at 5, 18, 30, 41, 46, 50, 57 dBZ

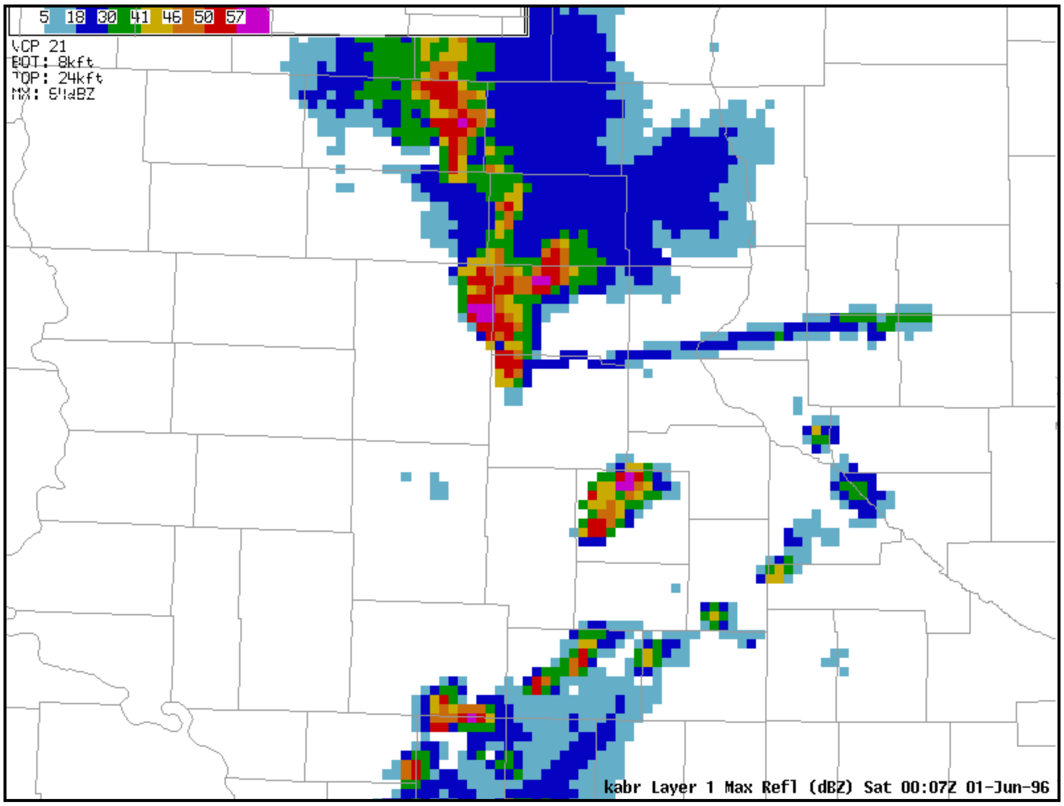


Figure 3-16. Layer Composite Reflectivity Maximum (LRM) product - low layer with base at 8,000 ft MSL.

LRM Limitations

1. Mid & Low layer products will use few elevation angles at long distances.
2. Mid and High level products are ineffective at close range due to the cone of silence.
3. Low layer product susceptible to non-precipitation echoes.

LRM Strengths/ Applications

1. Mid-High layer products used to estimate the height of higher reflectivities.

2. Comparison of Base Reflectivity and Mid or High Layer Composite Reflectivity Maximum product may aid in determining a storm's intensity trend.
3. Use mid level product to help differentiate real echoes from ground clutter.

User Selectable Layer Reflectivity Maximum (ULR)

The User Selectable Layer Reflectivity Maximum (ULR) product allows the user to select a specific, customized layer of reflectivity. The ULR offers the capability for the user to select both the lower and upper levels to design a product which will meet various forecasting needs such as a better understanding of storm structure and potential levels of icing (Bright Banding).

ULR Product Characteristics

The minimum thickness of the selected layer is 1 kft and altitudes from 0 to 70 kft may be selected. The ULR is a polar gridded product (note the LRM and LRA products are rectangularly gridded). The ULR's resolution is 1 km (.54 nm) x 1° and has a range of 230 km (124 nm). The Layer Composite Reflectivity task (RPG) allows up to 10 layers per volume scan. However, AWIPS only stores the most recent version per volume scan. This is expected to be corrected in AWIPS OB5.0. Non-associated Users can only get previously generated products by doing one-time requests.

ULR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: User Selectable Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

ULR product annotations

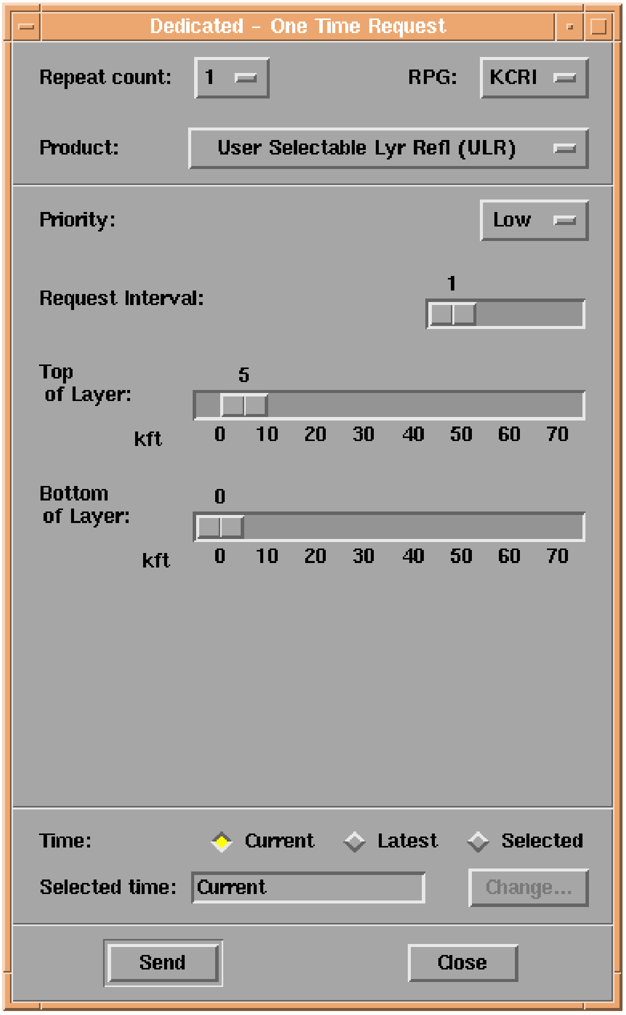


Figure 3-17. User Selectable Layer Reflectivity Maximum (ULR) One Time Request Window.

- VCP: 11, 12, 21, 121, 31 or 32
- BOT: Bottom of the layer in kft
- TOP: Top of the layer in kft
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the maximum value for the entire product
- Additional ULR product characteristics
- RANGE: 124 nm

- RESOLUTION: 1° x 0.54 nm
- DATA LEVELS: 16 data levels

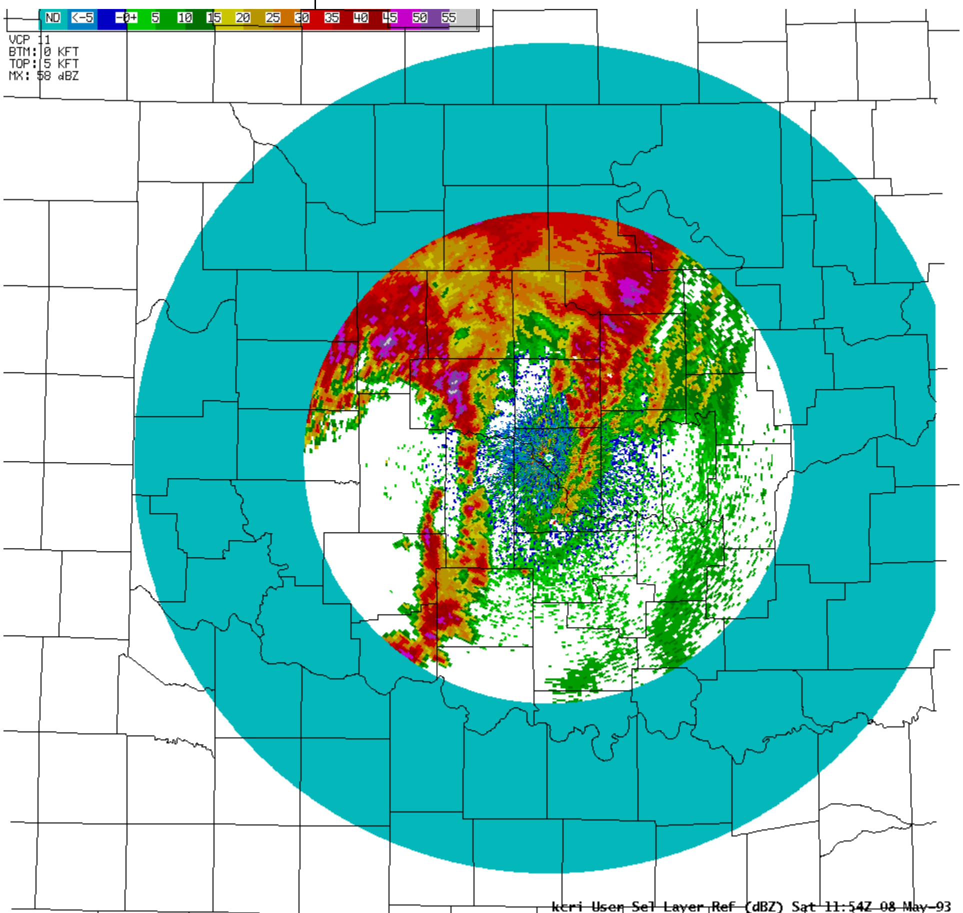


Figure 3-18. User Selectable Layer Reflectivity (ULR) product

ULR Limitations

1. Height of data within selected layer is unavailable.
2. Shallow layers will often have concentric circles (stepped appearance) due to sampling (limited elevation angles through layer).

ULR Strengths

1. Layer can be selected to meet user needs.
2. Has higher resolution and more data levels than LRM products.
3. Can be used to locate bright band.
4. Help locate storms with significant hail threat by looking at a layer centered on -20^{o}C

Enhanced Echo Tops (EET)

Definitions

Cell Top - Height of highest component (>30 dBZ) above radar level (ARL)

Echo Top - Height of the 18 dBZ (default) echo in MSL.

Process

The Enhanced Echo Top product locates the highest elevation angle where ***reflectivity ≥ 18 dBZ*** (default) for each ***0.54 nm x 1 degree grid box.*** Interpolation occurs between elevations slices.

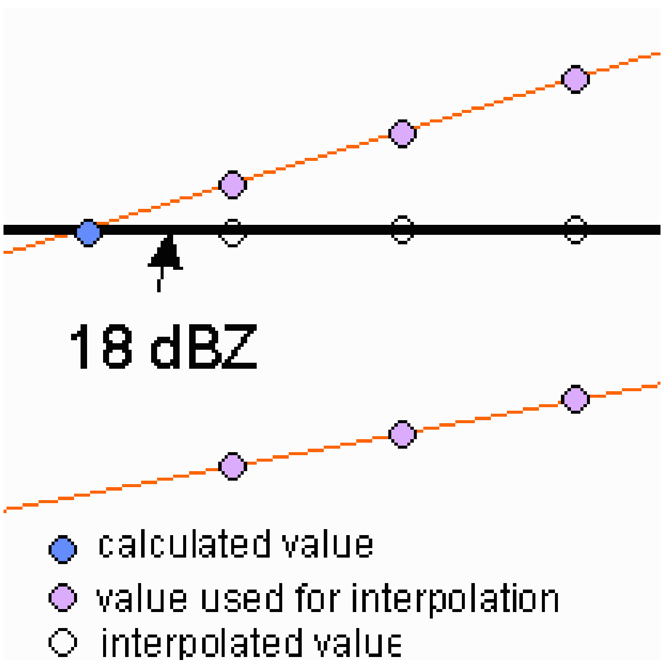


Figure 3-19. Interpolation between elevations in EET product

In areas where reflectivities exceed 18 dBZ on the highest elevation angle (i.e., 19.5 degrees. in VCP 11, 12, 21, 121) the height is tagged as “topped”. See Figure 3-20 for an example of the EET product.

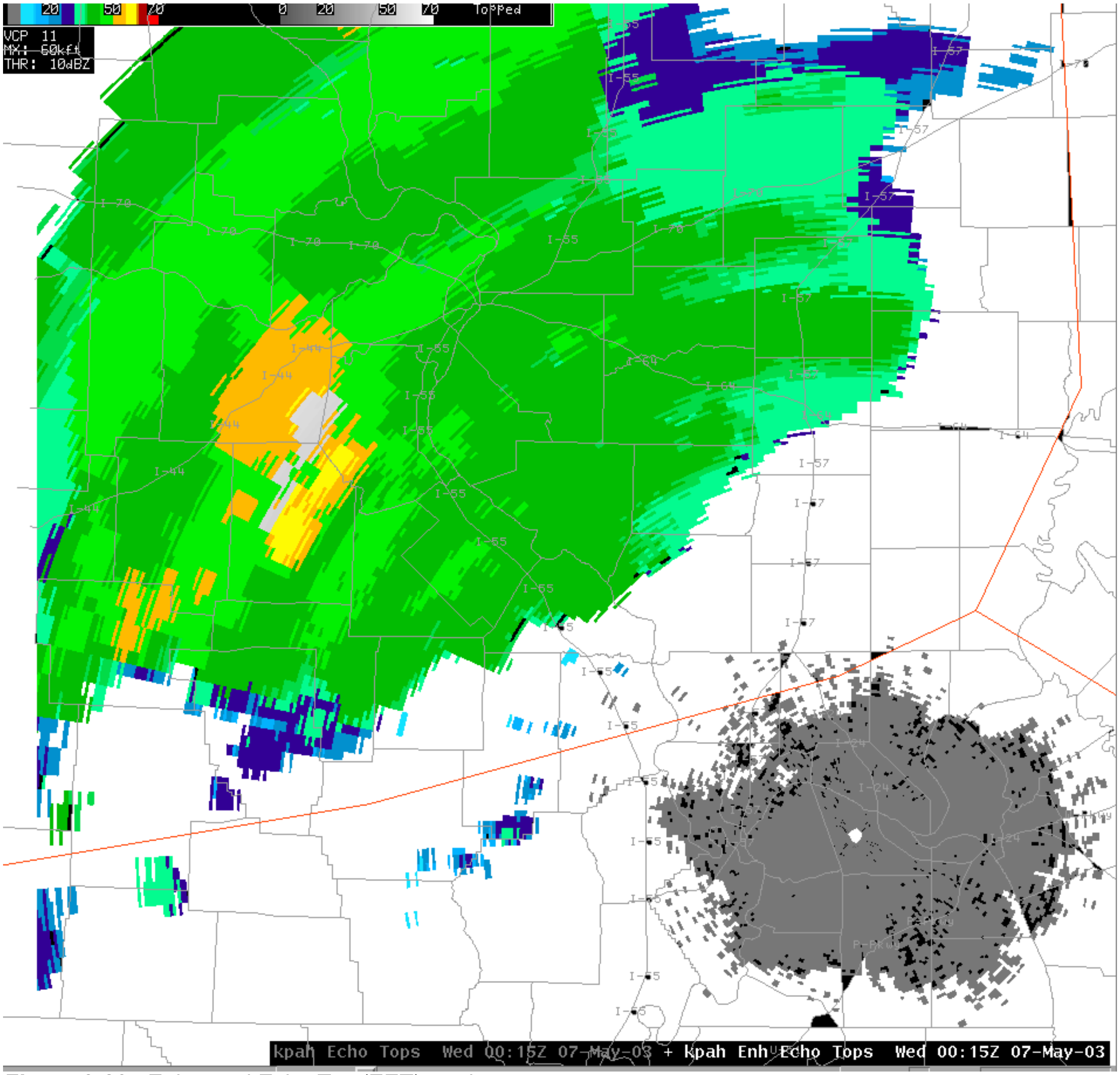


Figure 3-20. Enhanced Echo Top (EET) product

EET Product Parameters

EET product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Enh Echo Tops
- UNITS: kft
- DATE: Day of week, time, and date in UTC

EET product annotations

- VCP: 11, 12. 21, 121, 31 or 32
- MX: This is the maximum height (kft) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the max value for the entire product.
- THR: This is the threshold used to define the echo. Default is 18 dBZ.

Additional EET product characteristics:

- RANGE: 124 nm
- RESOLUTION: 0.54 nm (1 km) x 1 degree
- DATA LEVELS: 256 Data levels - values range from 0 kft to 70 kft with separate color scale (usually gray scale) for “topped” 0 kft to 70 kft

EET Limitations

1. **A circular stair-stepped appearance will often be evident** due to use of discrete elevation sampling.
2. Side lobes may result in <u>overestimated</u> tops.

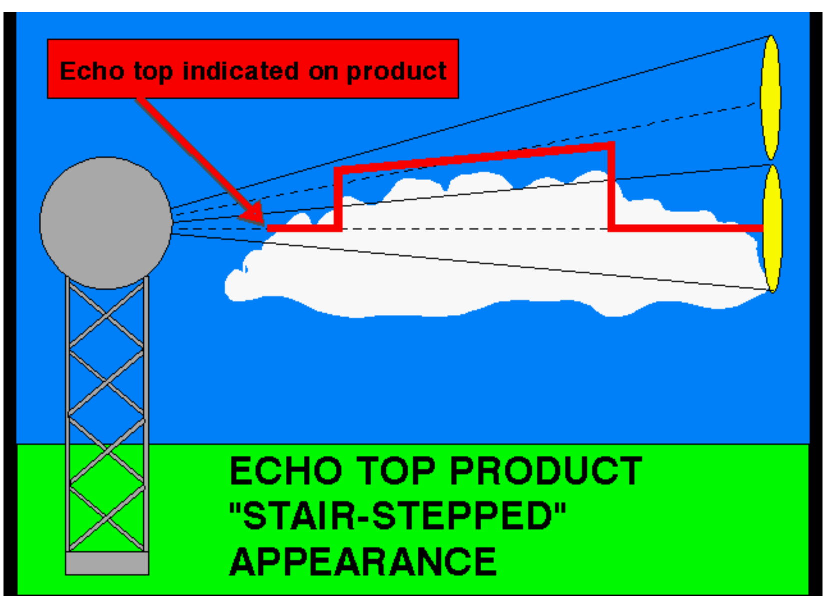


Figure 3-21. Echo Top product stair-stepped appearance.

3. Tops will be underestimated close to the radar due to the cone of silence (coded as “topped”).

EET Applications / Strengths

1. **Quick estimation of the most intense convection**; higher echo tops.
2. Assist in differentiating non-precipitation echoes from real storms.
3. Aids in identification of storm structure features such as tilt, updraft flank, max top over strong low level reflectivity gradient, etc.
4. May detect mid-level echoes before low-level echoes are detected.

Interim Summary

Composite Reflectivity (CZ)

1. Displays the maximum reflectivity for each vertical resolution grid box.
2. Useful product to:
   - quickly identify most intense storms, &
   - determine where to create Reflectivity Cross Sections.
3. Combined Attributes Table is available with product.

Layer Composite Reflectivity Maximum (LRM)

1. Maximum reflectivity for a specified layer.
2. Mid or high layer product used to estimate height of higher reflectivities
3. Comparison of mid or high layer products and Base Reflectivity may help determine the intensity trend of storms.

User Selectable Layer Reflectivity (ULR)

1. Layer can be selected to meet user needs, such as bright band detection.
2. Has higher resolution and more data levels than LRM products.

Enhanced Echo Tops (EET)

1. Estimates height in MSL of $\geq$ 18 dBZ echo using interpolation between elevation angles.
2. Primary use of product is to identify storms with greater vertical development.
3. Aid in differentiating real echoes from non-precipitation echoes.

Lesson 4: Velocity Based Algorithms and Products

Overview

Velocity Derived Products are those which use the Base Velocity Data as their primary input. The benefit of these algorithms is that they quickly analyze the entire volume scan of velocity data and give the operator guidance as to which areas need additional investigation. Keep in mind that the Base Velocity Data used in these algorithms has already undergone dealiasing as well as range-unfolding before being ingested. As a result, problems such as dealiasing failures or range folding will occasionally make it more difficult for the Velocity Derived Algorithms to produce accurate information

Review

The WSR-88D measures only radial velocity.

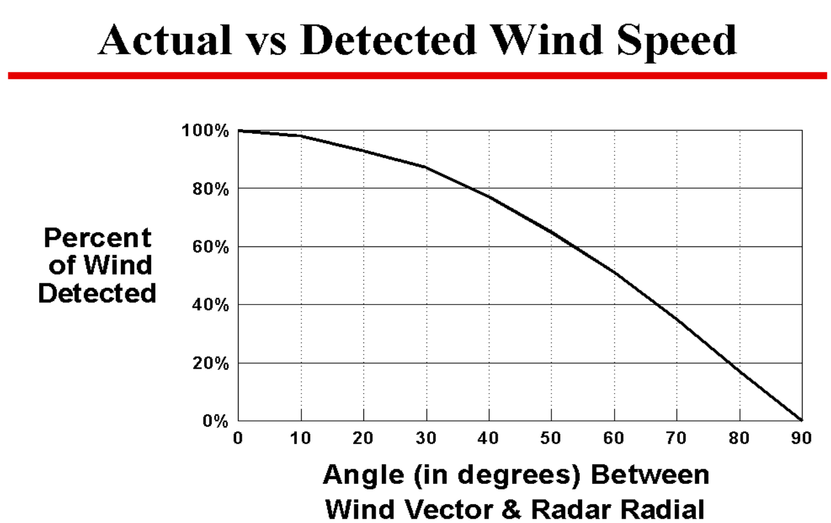


Figure 4-1. If the wind direction is directly down the radial, 100 percent of the velocity will be measured. If it is blowing perpendicular across the radial, 0 percent will be measured. Always keep this in mind when estimating wind speed from Doppler velocities.

Knowledge of where the RDA is in relation to the feature is also very important for proper interpretation. Use of the Polar Grid background map may help the operator to locate the radar when magnification is done.

Here is a quick review of some small scale signatures and their positions relative to the radar. Notice how the signatures look the same, but because the are in different locations relative to the radar, they would be interpreted differently.

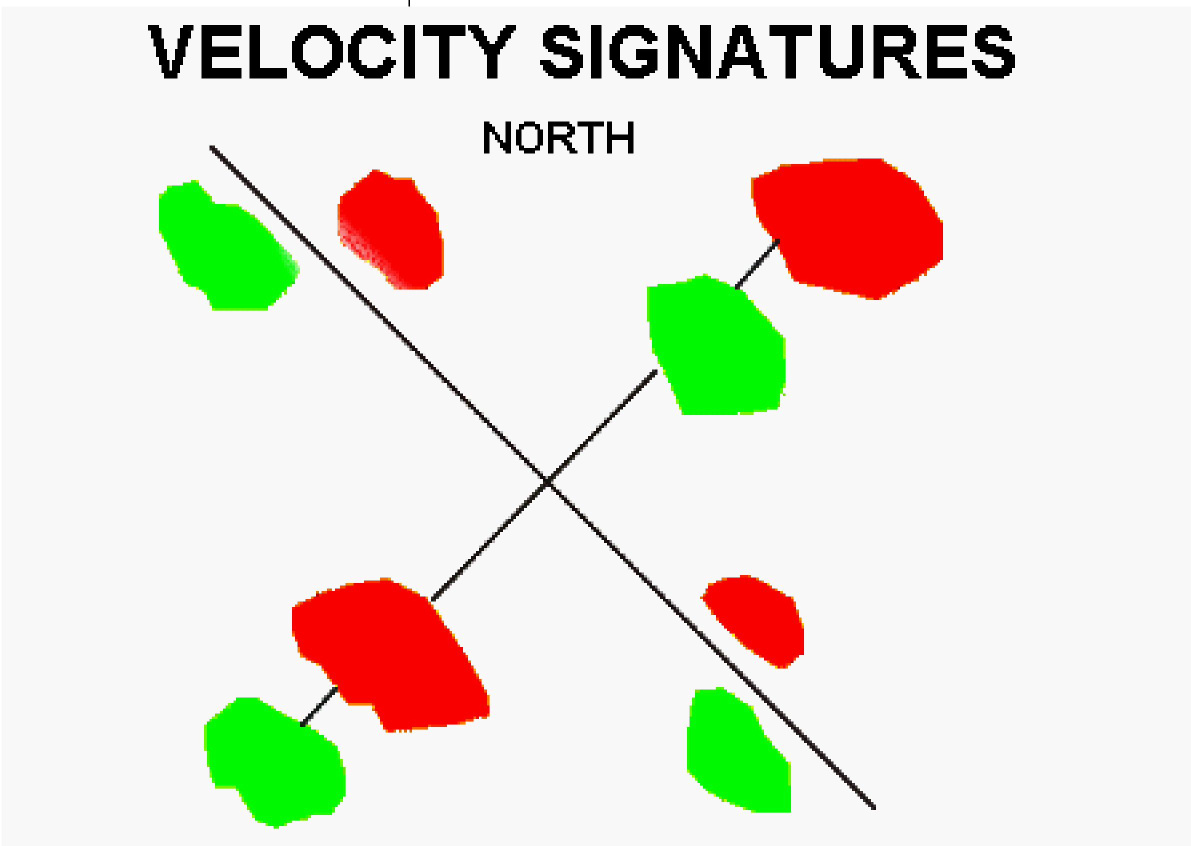


Figure 4-2. Small scale signatures.

Objectives

Without references and according to the lesson, you will be able to identify one strength and one limitation of the following velocity products:

1. 8-Bit Storm Relative Mean Radial Velocity Map (SRM)
2. Velocity Cross Section (VCS)
3. Velocity Azimuth Display (VAD)
4. Velocity Azimuth Display Wind Profile (VWP)

5. Mesocyclone Detection (MD)

6. Tornadic Vortex Signature (TVS)

7. TVS Rapid Update (TRU)

Storm Relative Mean Radial Velocity Map (SRM)

SRM Overview

A long name which will be shortened to SRM from here on out! The SRM is a 124 nm radius product of mean radial velocity with an estimated storm motion subtracted out.

In the example (See Fig. 4-3 on page 94.), the identical mesocyclone is displayed using a Base Velocity product (left) and the SRM Product (right). The storm is moving to the northeast at 40 kts. The Base Velocity is measuring both the circulation and the storm motion. Therefore, all we see is out-bound velocities (much stronger on the right side of the couplet). In the SRM, we take away the motion of the storm itself, leaving only the circulation. The couplet is now very apparent to the observer showing the classic signature for pure rotation. Unless you are very experienced, you might not suspect a circulation is present using base velocity alone. However by looking at the SRM, you can now take steps to evaluate the strength of the circulation and determine a course of action.

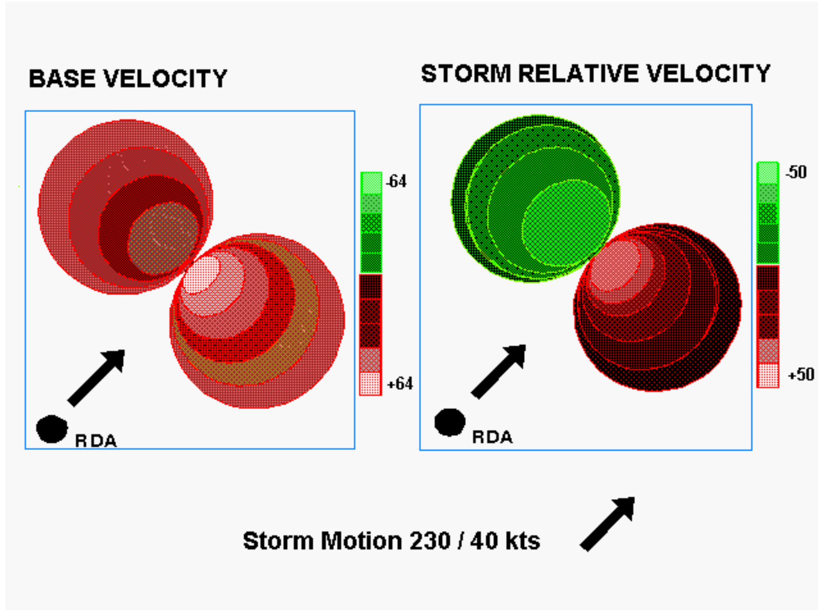


Figure 4-3. When storm motion is subtracted, circulations are easier to see.

Default Storm Motion

Estimated storm speed and direction used by the algorithm will default to the ***average motion of all storms*** from the Storm Track Information Product (from the previous completed volume scan). Keep in mind the limitations of the SCIT algorithm which can cause erroneous storm motions to be generated. If these errors occur, they will be passed along to this algorithm.

Operator Input Storm Motion

To override this, speed and direction can be input by an AWIPS operator on a one-time request basis to an associated RPG. The Repeat Count Function may be used. Only SRM with the default motion subtracted can be received from Non-associated RPGs.

Note: The One-Time Request window is used to input operator defined motions for the standard (4-bit) SRM products. A different window or Graphical User Interface (GUI) is used to input a user defined motion for the 8-bit SRM covered next.

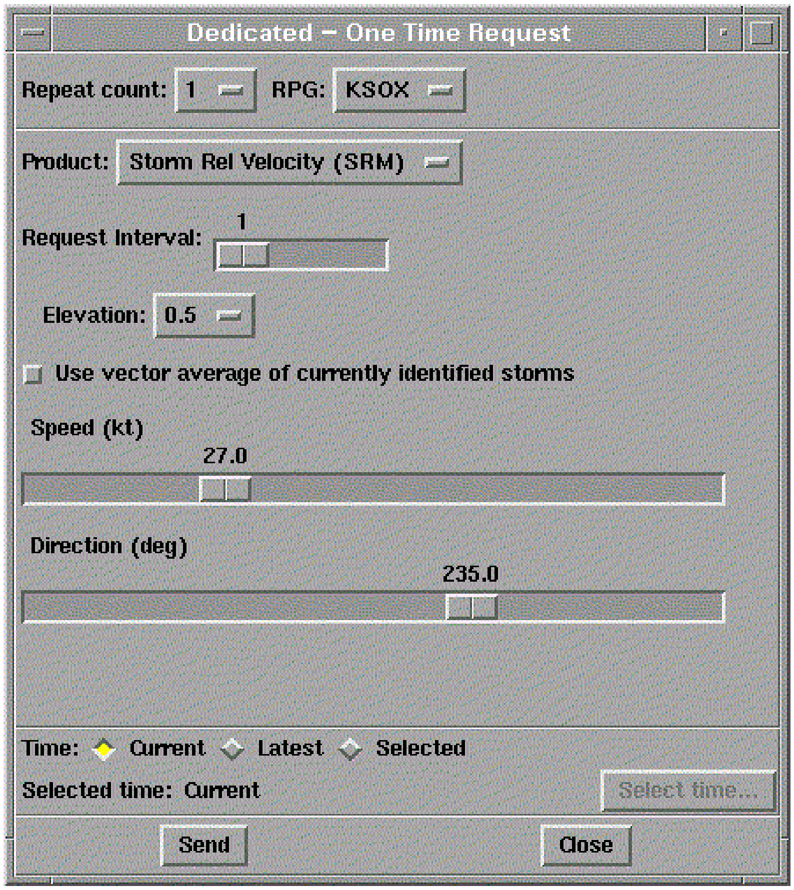


Figure 4-4. Operator input storm motion of 235° at 27 kts.

Product Uses

SRM is useful in detecting shear regions

1) Mesocyclone

2) TVS

3) Upper level divergence

What feature are you attempting to see? When using Storm Relative products you should always consider your frame of reference. If you are interested in the rotation within a storm, use Storm Relative products. If you are interested in ground relative winds, (i.e., winds associated with a gust front) use the base velocity products.

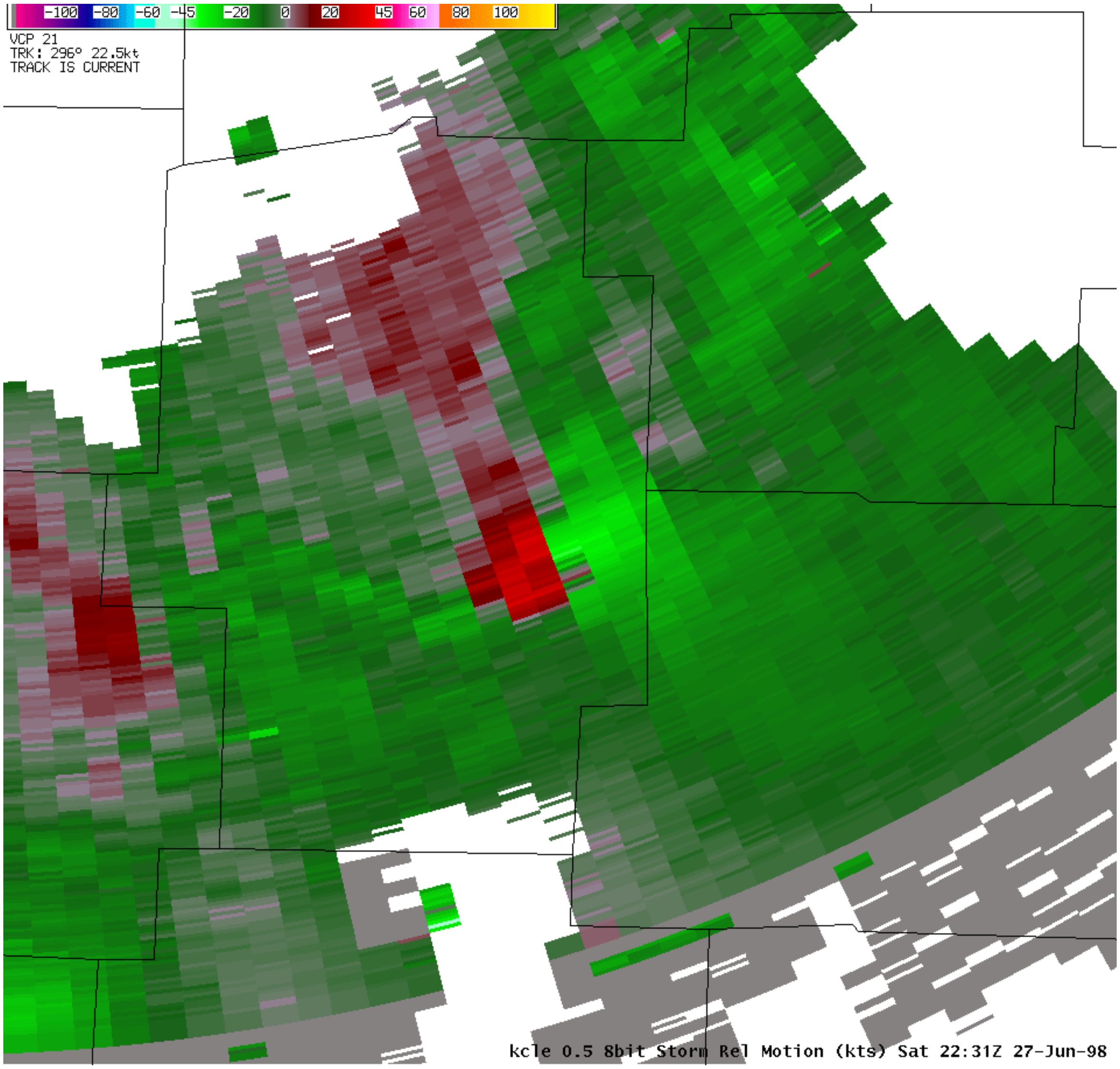


Figure 4-5. Storm Relative Mean Radial Velocity Map (SRM) product (8-bit)

8-bit SRM

Process

The 8-bit (256 data level) SRM is a display produced "on-the-fly" by AWIPS using data from the 8-bit Base Velocity product. The 8-bit SRM is not a product produced by the RPG, therefore it is not archived as such. To obtain an 8-bit SRM display you must first have the corresponding 8-bit Velocity product in the AWIPS data base, by either including the 8-bit Velocity on the RPS list or by One-Time Request.

The 8-bit SRM storm motion can be set three ways:

1. The last storm motion set by WarnGen or the distance speed tool.
2. The average storm motion calculated by SCIT. (Same as the default storm motion for the regular 4-bit SRM)
3. Operator motion as set in the Radar Storm Motion Vector graphical user interface.

The decision on which of these three methods are used to set the storm motion is made by the user using the Radar Display Controls (See Fig. 4-6).

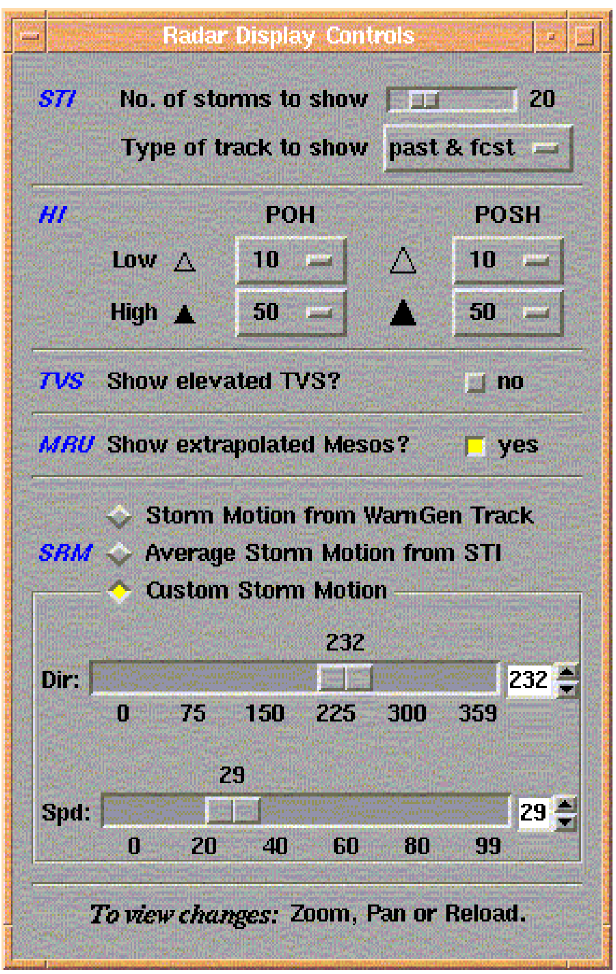


Figure 4-6. Operator input storm motion of 232° at 29 kts.

Product Uses

The 8-bit SRM product displays the highest resolution velocity data available from the radar out to 124 nm. When compared to the standard 4-bit SRM, it has greater detail spatially and in data magnitudes.

Product Description

8-bit SRM product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: in degrees (any one in current VCP)
- PRODUCT NAME: 8-bit Storm Rel Vel - Map
- UNITS: kts (nautical miles per hour)
- DATE: Day of week, time, and date **in UTC**

8-bit SRM product annotations:

- VCP: VCP 11, 12, 21, 121, 31 or 32
- TRK: This is the storm motion which has been subtracted out (average of all identified cells). The direction in degrees and speed in kts.
- TRACK IS Current: This is the user supplied (either from Radar Display Controls or from WarnGen) storm motion which has been subtracted out. The direction in degrees and speed in kts.
- TRACK is Default: This is the SCIT Algorithm supplied storm motion. The average cell motion of all SCIT identified cells.

Additional 8-bit SRM product characteristics

- RANGE: 124 nm
- DATA LEVELS: 256
  - Usually defaults to purple or white for range folded data.

8-Bit SRM Limitations

1. RPS list size restrictions may limit availability of needed 8-bit Base Velocity products to produce 8-bit SRM.
2. Care must be taken to ensure a representative storm motion is being produced by the default motion setting chosen.
3. The 8-bit Base Velocity products used by AWIPS to produce the 8-bit SRM are large and **can produce narrowband loadshedding** unless a LAN-to-LAN connection is used.
4. It is more difficult to determine actual ground-relative winds.

8-bit SRM Strengths/ Applications

1. **High detail both spatially and in data magnitude** can provide improved detection of TVSs, Mesocyclones, Microbursts, and Boundaries.
2. Same data levels and color scales can be used for both Clear Air Mode and Precipitation Mode VCPs.
3. High Storm Relative Velocities (up to 248 kts) are displayable and viewable on cursor readout sampling.
4. Very useful for examining the velocity structure of fast moving storms (> 10 knots).

4-bit SRM Product Description:

SRM 4-bit product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: in degrees (any one in current VCP)
- PRODUCT NAME: Storm Rel Vel - Map
- UNITS: kts (nautical miles per hour)
- DATE: Day of week, time, and date **in UTC**

SRM product annotations:

- VCP: VCP 11, 12, 21, 121, 31 or 32

- ALG: This is the default storm motion which has been subtracted out (average of all identified cells). The direction in degrees and speed in kts.
- USR: This is the user supplied storm motion which has been subtracted out. The direction in degrees and speed in kts.
- MN: This is the strongest inbound (negative) velocity detected on the product. The location of this value is unknown, and this is a Storm Relative value.
- MX: This is the strongest outbound (positive) velocity detected on the product. The location of this value is unknown, and this is a Storm Relative value.

Additional SRM product characteristics

- RANGE: 124 nm
- DATA LEVELS:
  - 16 data levels from -50 kts to +50 kts, with one level (usually purple or white) for range folded data.
  - Data levels cannot be changed on the SRM.
  - Data levels are ***lower bound***. (For example, 22 kt data level can range from 22-29 kts.)

To investigate a storm three-dimensionally, it is recommended that you put at least 4 elevation cuts on your RPS List to be viewed in a 4-panel presentation or several slices to be viewed in the all tilts mode. The slices you choose should be the same as those selected for Base Reflectivity products on your RPS List. The angles you choose will of course depend on the vertical extent of the storm as well as the range to the storm. However, it is always advisable to have a 0.5° Base Velocity on the RPS list to determine ground-relative winds.

4-bit SRM Strengths and Limitations

The strengths and limitations for the 4-bit SRM products are essentially the same as for the 8-bit products, only resolution is less and the displayable magnitudes of the velocity values are less, both making the 8-bit SRM more useful. However, the 4-bit products file sizes are much smaller, and therefore require less bandwidth, and do not necessarily need user input for storm motion.

Velocity Cross Section (VCS)

VCS Overview

The Velocity Cross Section is a cross section of the Base Velocity data. This product is produced in a similar manner as the Reflectivity Cross Section (RCS). ***Interpolation*** is used to fill data gaps. Although the horizontal resolution of the product is 0.54nm, the VCS uses the maximum value of every four 0.13nm range bins. Therefore, values displayed on the VCS may appear higher than on the 0.54nm Base Velocity products.

As with RCS, the two points picked must be within 124 nm of the RDA and no more than 124 nm apart.

Since radial base velocity data is used to produce the VCS, it is strongly suggested that the VCS be generated using two points either***:***

- ***along a radial*** to see convergent/divergent signatures and/or updraft/downdraft interface
- ***over a short distance perpendicular to the radial*** to see rotation.

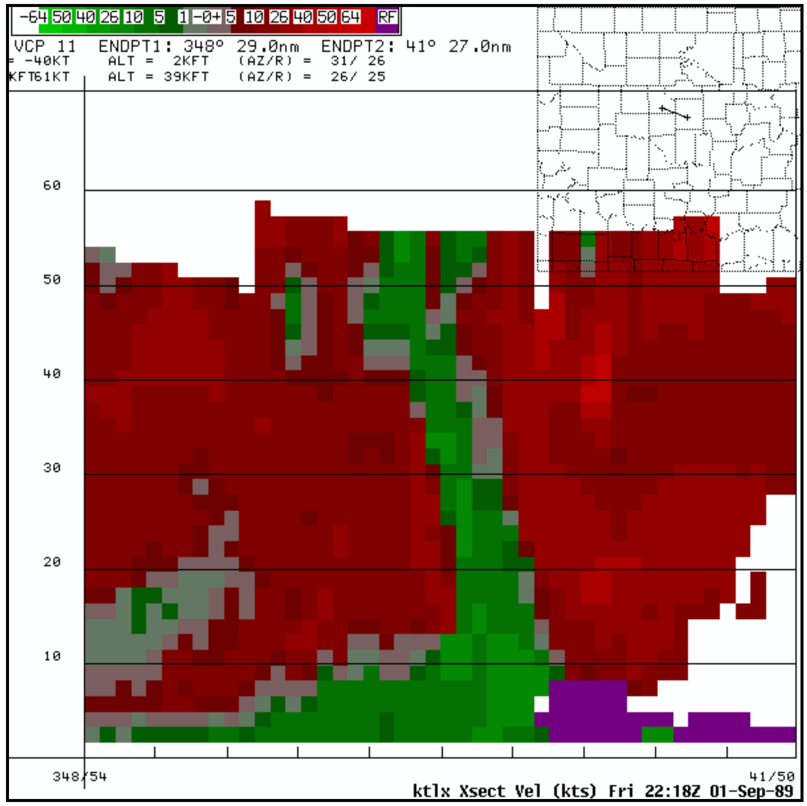


Figure 4-7. Velocity Cross Section (VCS) product. Note geographic location in upper right corner.

Useful product, but not recommended for RPS list - Use this as a supplemental product, particularly in a research mode.

VCS Adaptable Parameters

If the user changes the velocity data levels for the Base Velocity products ***at the RPG HCI***, this will also change the data levels for the VCS.

VCS Product Characteristics

The Velocity Cross Section has the following characteristics:

- RESOLUTION: 0.54 nm horizontal res X 0.27 nm vertical res.
- COVERAGE: 124nm X 70,000 ft
- DATA LEVELS: 8 or 16 data levels
- Height on Z axis in 10,000 ft intervals.
- Range on x/y axis depends upon length of cross section (the endpoints are in km).

- Left side of product is western most point chosen (ENDPT1), unless along the same longitude, then the northern point will be on the left side (ENDPT2).

VCS Product Parameters

See Fig. 4-7 for an example of the VCS Product

VCS product legend description

- RPG ID: kxxx
- PRODUCT NAME: Xsect Vel
- UNITS: kts
- DATE: Day of week, time, and date in UTC

VCS product annotations

- VCP: 11, 12, 21, 121, 31, or 32
- ENDPT 1: AZRAN of the western-most point (nm)
- ENDPT 2: AZRAN of the eastern-most point (nm)
- MIN (inbound) velocity, ALTitude (ARL in kft), AZ/R (AZRAN in degrees and nm)
- MAX (outbound) velocity, ALTitude (ARL in kft), AZ/R (AZRAN in degrees and nm)

VCS Limitations

1. ***Doppler velocities are relative to the RDA.*** As stressed in Velocity Interpretation, you must always know where the phenomenon is in relation to the RDA. This increases the importance of baseline map in the upper right of the cross section.
2. ***Height exaggerated versus range*** (70,000 ft vs. up to 124 nm range). This is the same limitation observed in the RCS product. Features are not to scale, and appear thinner and taller than they actually are.

3. ***Interpolation may enlarge or miss features.*** Just as with the RCS product, gaps in the VCP will result in interpolations which may smooth out or enlarge a particular feature (especially in VCP 21).

4. ***Storm Relative cross section is NOT available. This may make it difficult to interpret signatures in especially fast moving storms.***

5. ***Storm top divergence estimates are limited due to radar viewing angle and data thresholds.*** Difficult to determine hail larger than golf ball size using NSSL criteria unless both maxima listed on the top of the grid are close to the the storm summit.

* Remember, a VCS perpendicular to the radial can be used to see rotation, while a VCS along a radial can be used to see convergence/divergence. However, the ability to see features with the cross section products is highly dependent upon placement of the cross section. A 4-panel velocity or SRM (or use all of the tilts) will probably get better results.

VCS Strengths/ Applications

1. Aid in determining storm structure features such as:
   - Inferring location of updrafts/downdrafts
   - Strength of storm top divergence
   - Depth of mesocyclones
2. Has proven very valuable for kinematic insights in a research setting.

Interim Summary

8-bit SRM

1. Generated by AWIPS using the 8-bit Base Velocity at AWIPS.
2. The user can set the storm motion to either the last motion used by WarnGen, the average motion of all storms from Storm Track algorithm, or that directly input by the operator.
3. Provides higher spatial resolution (0.13 nm vs. 0.54 nm) and greater number of data levels (256 vs. 16) than the 4-bit SRM product.
4. Aid in determining shear regions and storm top divergence which may be obscured by storm motion.
5. Especially useful with faster moving storms.

4-bit SRM

1. Storm motion subtracted from Base Velocity data at the RPG.
2. Storm motion defaults to average motion of all storms from Storm Track algorithm, but operator may input motion.

Velocity Cross Section

1. Vertical cross section of the Base Velocity data.
2. Should be generated either along a radial to see convergent or divergent signatures, or over short distances perpendicular to a radial to see rotation.
3. Aid in inferring updraft/downdraft interface locations, storm top divergence and the depth of mesocyclones.

Velocity Azimuth Display (VAD)

VAD Overview

Although the VAD product is not a commonly used product, the VAD winds are output to two important places -- the VAD Wind Profile (VWP) Product and the Environmental Winds Table. Therefore, an understanding of the VAD Algorithm and VAD product is important.

You have used the Base Velocity products and attempted to infer wind speed and direction at a particular height (range) by using the zero isodop. The VAD algorithm attempts to do this at several heights. The VAD Product is a scattering of data points used to compute the wind speed and direction for a given height. Although only radial velocity (inbound or outbound) is measured at a given point, the radial velocities 360 degrees around the radar at a given height (range) can produce an estimate of the average wind speed, and actual wind direction (i.e., the azimuth of the strongest inbound wind approximates the direction the wind is coming from).

Algorithm Methodology

Slant Range

1. The VAD winds are computed using a single elevation angle at a constant ***slant range***. For each altitude requested on the VAD Wind Profile, the VAD Algorithm selects the elevation angle that is closest to intersecting that altitude at the ***VAD range*** (adaptable parameter with a default of 30 km or 16.2 nm). The actual slant range will change dependent upon the altitude for which the VAD wind is being calculated (See Fig. 4-8 on page 107.).

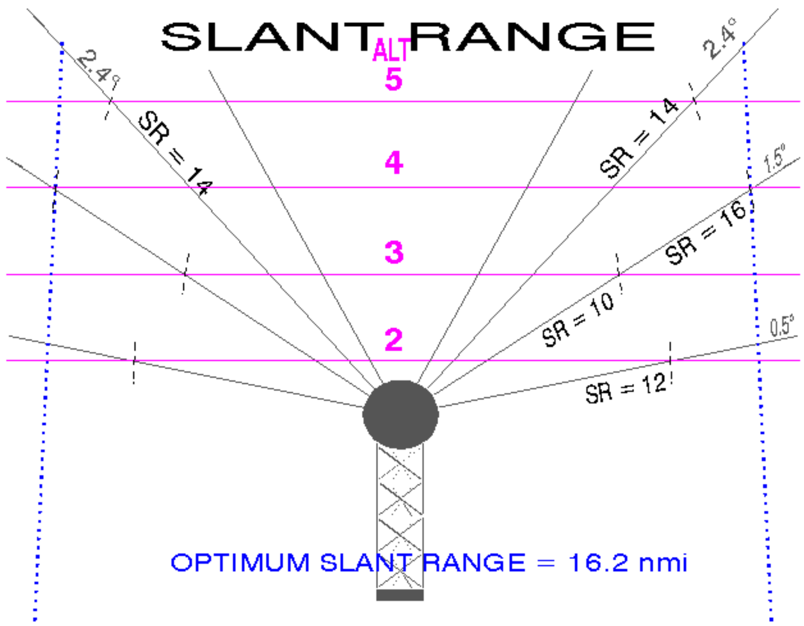


Figure 4-8. Slant Range

Velocity Data Plotted

2. ***A 0.13 nm resolution base velocity data point is plotted on a graph at each azimuth.*** The x-axis on the graph is azimuth (0°/360° for N, 180° for S of the RDA), and the z-axis is velocity (positive outbound velocities at the top and negative inbound velocities at the bottom).

Sine Wave Fit to the Data

3. If there are ***25 data points*** plotted on the graph, the algorithm then computes a ***sine wave*** to fit to the data (using least squares fit method). The VAD wind is computed from this sine wave. The amplitude of the sine wave is the estimated wind speed. The strongest inbound portion of the sine wave (closest to the bottom of the graph) becomes the estimated wind direction.

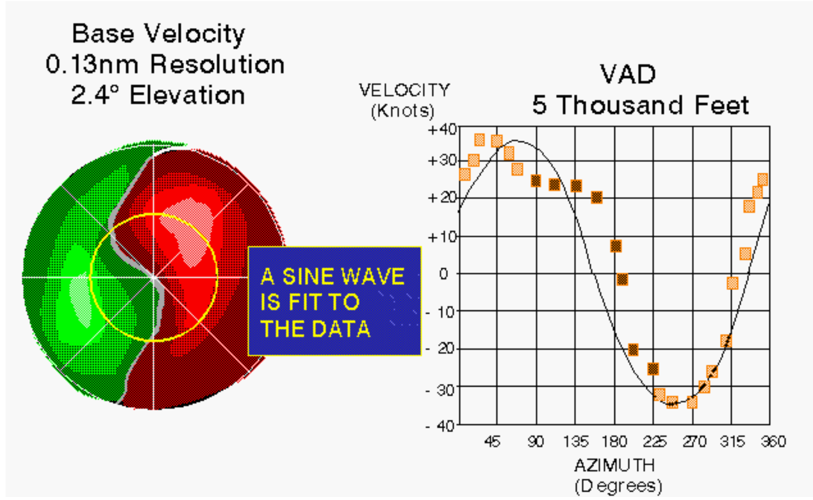


Figure 4-9. VAD data fit.

Symmetry and RMS error

4. Two additional values are calculated -- ***Symmetry and RMS error. Symmetry*** is the difference in knots between the zero velocity line on the VAD coordinate system and the median line of the sine wave curve. If the symmetry is negative (median line below the zero line) the inbound winds are stronger than the outbound indicating convergent flow at the radar site. Positive symmetry indicates diverging wind. ***RMS error*** (Root Mean Square error) is a calculation of the variation of the winds from the plotted sine wave. ***RMS error can be used as an indicator of the reliability of the wind estimate.***

If the symmetry exceeds 13.6 kts, or the RMS error exceeds 9.7 kts (ROC adaptable parameters), the winds can be determined by the operator using the plotted sine wave, but will not be output to the VAD Wind Profile (VWP) product.

VAD Altitudes

The VAD is available only for heights requested on VAD Wind Profile (VWP). These heights are determined by the user at the VAD and RCM Height Selection screen ***at the RPG HCI*** (URC adaptable). See Figure 4-10.

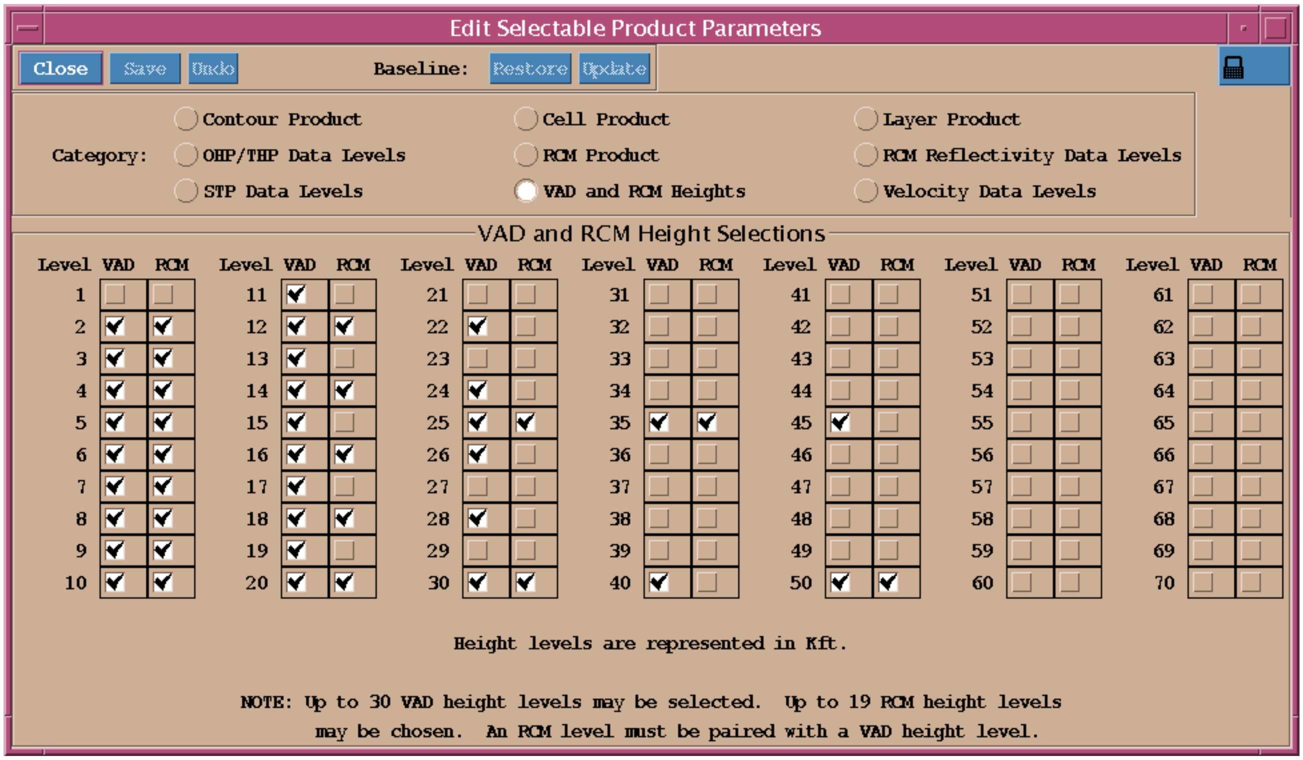


Figure 4-10. VAD Height Selection screen at the RPG HCI.

VAD Adaptable Parameters

There are three VAD adaptable parameters of importance: range, beginning azimuth and ending azimuth. They are edited at ***the RPG HCI***. See Figure 4-11.

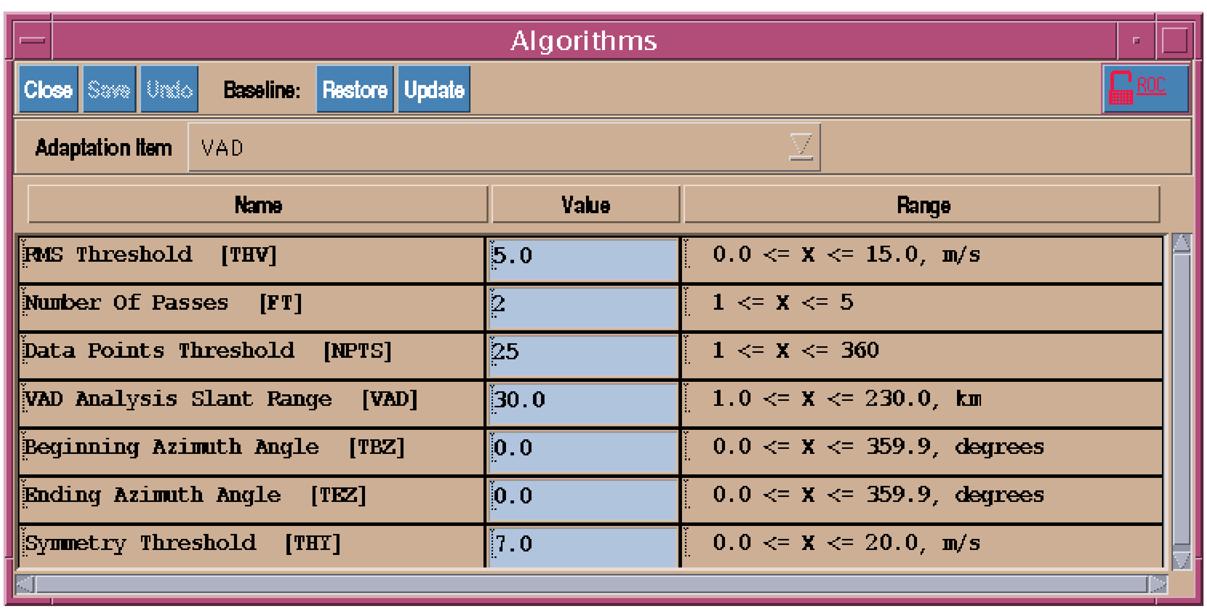


Figure 4-11. VAD Adaptable Parameters edit screen at the RPG HCI.

Output to the Environmental Winds Table

VAD winds are also output to the Environmental Winds Table used in the Velocity Dealiasing Algorithm. If the VAD winds are bad, the RPG HCI operator can turn off Auto Update, and manually input winds from a raob or profiler. See Figure 4-12.

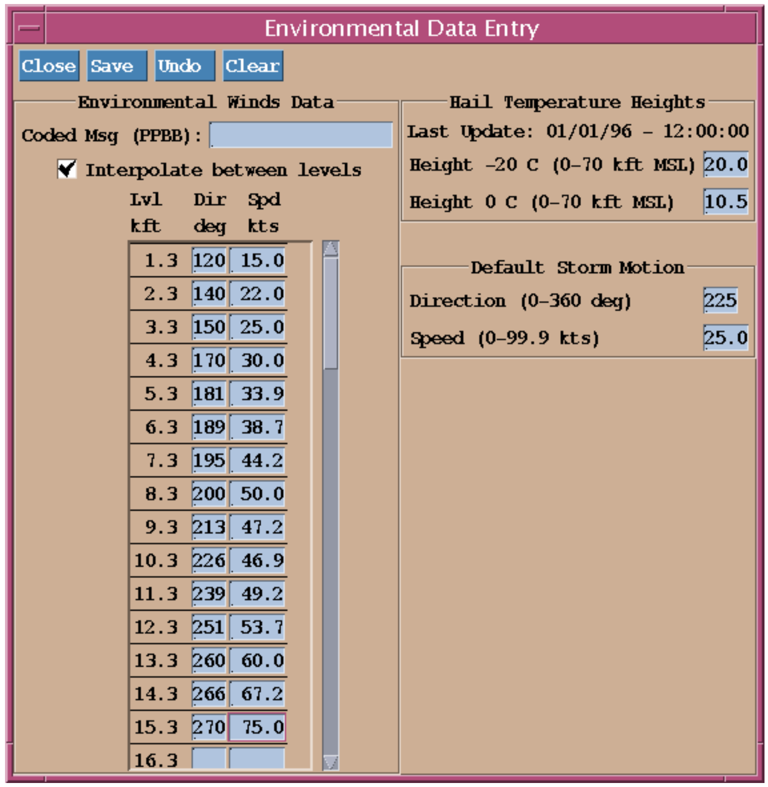


Figure 4-12. Environmental Winds Edit screen at the RPG HCI.

The VAD can be put on the RPS list or is available as a one-time request. The parameter that must be selected is the height in kft. See Figure 4-13.

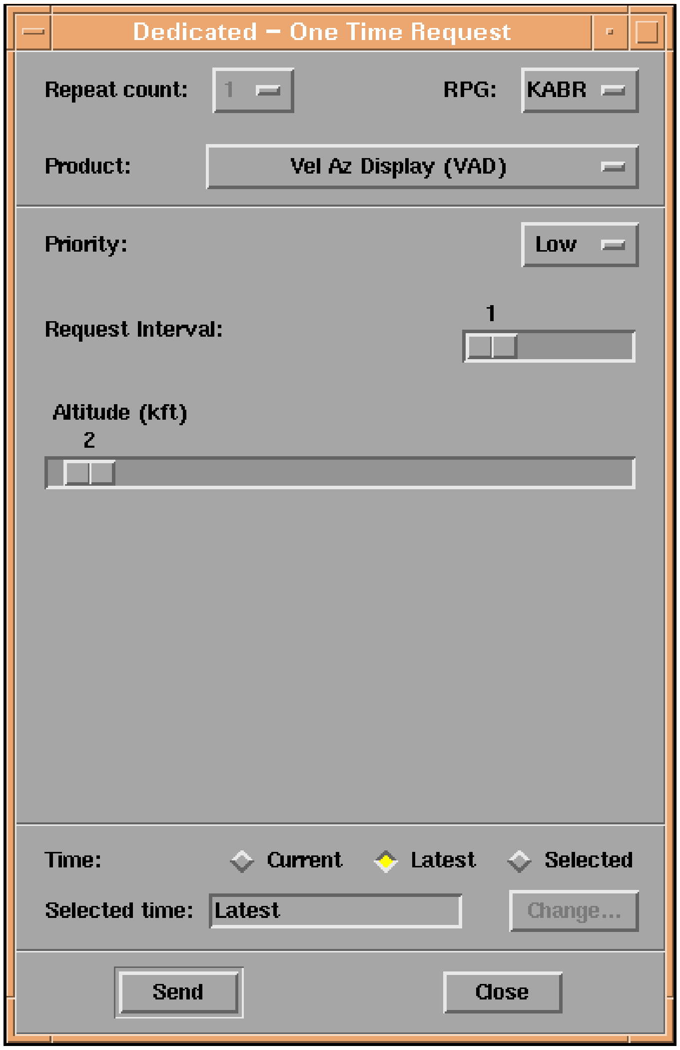


Figure 4-13. VAD product request screen.

VAD Product Parameters

See Figure 4-14 for an example of the VAD product

VAD product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Velocity Azimuth Disp
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

VAD Product Annotations

- VCP: 11, 12, 21, 121, 31 or 32

- ALT: Height in kft
- ELEV: Elevation angle that intersects selected height at the VAD range
- RNG: VAD Range
- WND: Wind direction and speed
- RMS: Root Mean Square error

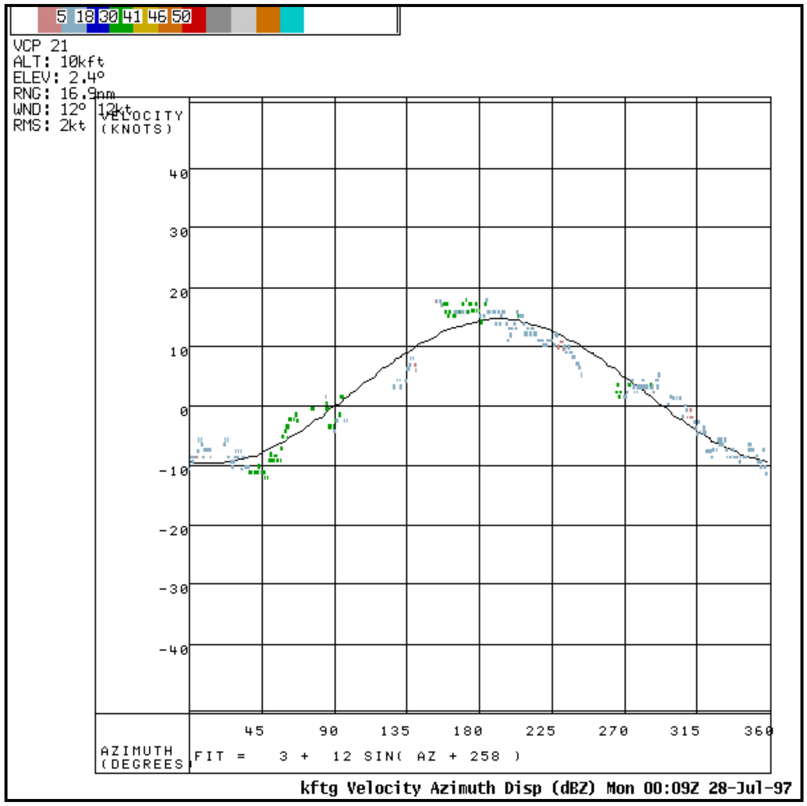


Figure 4-14. Velocity Azimuth Display (VAD) product.

VAD Limitations

1. ***Needs sufficient data points*** - Clear, cold, dry air often lacks scatterers. No sine wave will be plotted unless there are at least 25 data points.
2. ***May be unreliable in disturbed environments*** - The algorithm assumes horizontal uniformity of the wind field. If there is a front or boundary near the RDA, the data will often fail either RMS or symmetry thresholds.

3. ***Available for preestablished altitudes only*** - As designated at the RPG HCI for the VAD Wind Profile.
4. ***Large flocks of migrating birds may produce anomalous wind data.*** The averaging of the motion of birds in conjunction with the motion of the wind, can lead to erroneous wind data. Birds can cause the speed to be off by several knots and the direction to be off by several degrees. Typical symptoms include an "explosion of reflectivity returns in a "butterfly" pattern centered on the RDA just after sunset.

VAD Strengths/ Applications

1. ***VAD Winds are available in clear air or precipitation mode***. Generally speaking, the wind estimates will be slightly better in clear air mode since the radar antenna rotation is slower.
2. ***The VAD algorithm does not require 360 degrees of data.*** The algorithm only requires 25 data points (a sample from 25 degrees of azimuth), and they don't have to be contiguous. It is possible to only sample a certain sector to produce the VAD winds. For example you could decide to only sample the area between 135° and 225° to get an estimate of the winds ahead of the front. The "Beginning" and "Ending" azimuth is set at the RPG HCI (under URC Control).
3. ***Check missing or suspicious wind data on the VAD Wind Profile (VWP)*** - This is probably the primary reason many operators choose to look at the VAD Product. When you see "ND" plotted on the VAD Wind Profile, you can request the VAD at that altitude and see what happened: no sine wave could be plotted due to high RMS error (>9.7 kts), convergence or divergence in the wind flow produced a symmetry error exceeding limits (>13.6 kts), or too few data points (<25).

4. ***Update Environmental Winds Table. The VAD winds are fed into the Environmental Winds Table for use in the velocity dealiasing algorithm. This helps minimize dealiasing errors.***

VAD Wind Profile (VWP)

VWP Overview

The VAD Wind Profile Product (VWP) is a vertical profile of VAD-derived winds at various levels. Winds are plotted on a grid with the X-axis as time and the Z-axis as height in thousands of feet. As many as 11 profiles (11 volume scans) are plotted with the most recent profile at the far right side of the grid (opposite of the Wind Profiler Network time-height profiles).

Product Characteristics

The VAD Wind Profile (VWP) Product has the following characteristics:

- **Altitudes:** A maximum of 30 altitudes can be displayed each volume scan. The displayed MSL altitudes are selected at the RPG HCI. There must be a minimum of 1000 feet between levels. The lowest level selected should be the first altitude above the radar level (i.e., if the radar is at 2212 feet, then the lowest altitude selected should be 3 thousand feet). Altitudes to 70,000 feet can be selected, but winds above 45,000 feet are uncommon.
- **Wind Barbs:** Winds are displayed in the standard convention with the shaft always being the same length:
    - Small open circle - < 4 kts
    - 1/2 barb - 4-7 kts
    - full barb - 8-12 kts
    - flag triangle - 50 kts

- **Data Levels** - The data levels of the VWP represent the RMS error in kts of the VAD winds. Recall that the RMS error is a measure of how well the sampled data points fit the sine curve. The first data level represent RMS errors less than 4 kts, the second data level 4-7 kts, and the third data level 8-11 kts. Higher data levels will not be seen on the VWP since **"ND"** will be displayed if the RMS error exceeds 9.7 kts.
- **ND** - No Data will appear if:
    - there are fewer than 25 data points
    - RMS error greater than 9.7 kts, or
    - symmetry is greater than 13.6 kts

VWP Product Parameters

See Figure 4-15 for an example of the VWP product

VWP product legend description:

- RPG ID: kxxx
- PRODUCT NAME: VAD Wind Profile
- UNITS: RMS kts
- DATE: Day of week, time, and date in UTC

VWP product annotations

- VCP: 11, 12, 21, 121, 31 or 32
- HT(MX): Height of the maximum wind from the most recent volume scan.
- MXWND: Maximum wind direction and speed from the most recent volume scan.

VWP Adaptation Data

The VWP Adaptation Data can be displayed at the AWIPS Text Display Window (WSRVWPxxx). This can be used to determine the adaptable parameter settings used to generate the product. See Figure 4-16.

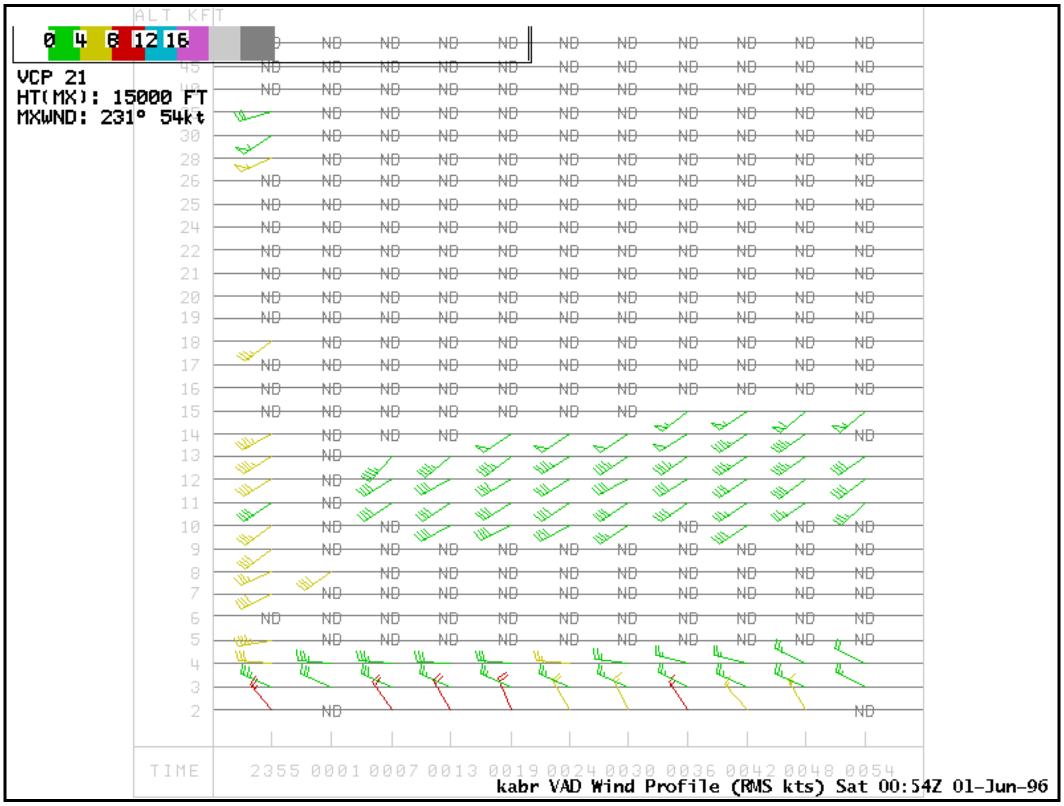


Figure 4-15. VAD Wind Profile (VWP) product.

VWP Hodograph

The VWP can be also be displayed as a hodograph in an AWIPS Interactive Skew-T using the following method.

1. Load WFO Scale and editable points (no need to load radar data)
2. Move a point to the RDA
3. Open the Volume Browser and choose VWP as the source, sounding as the field, and the point corresponding to the one over the RDA
4. Select Load

Several fixes and improvements to the VWP Hodograph are planned for in AWIPS Build OB3 including an option to merge with data from RUC or LAPS. The attached graphic depicts some of the errors in the OB2 version.

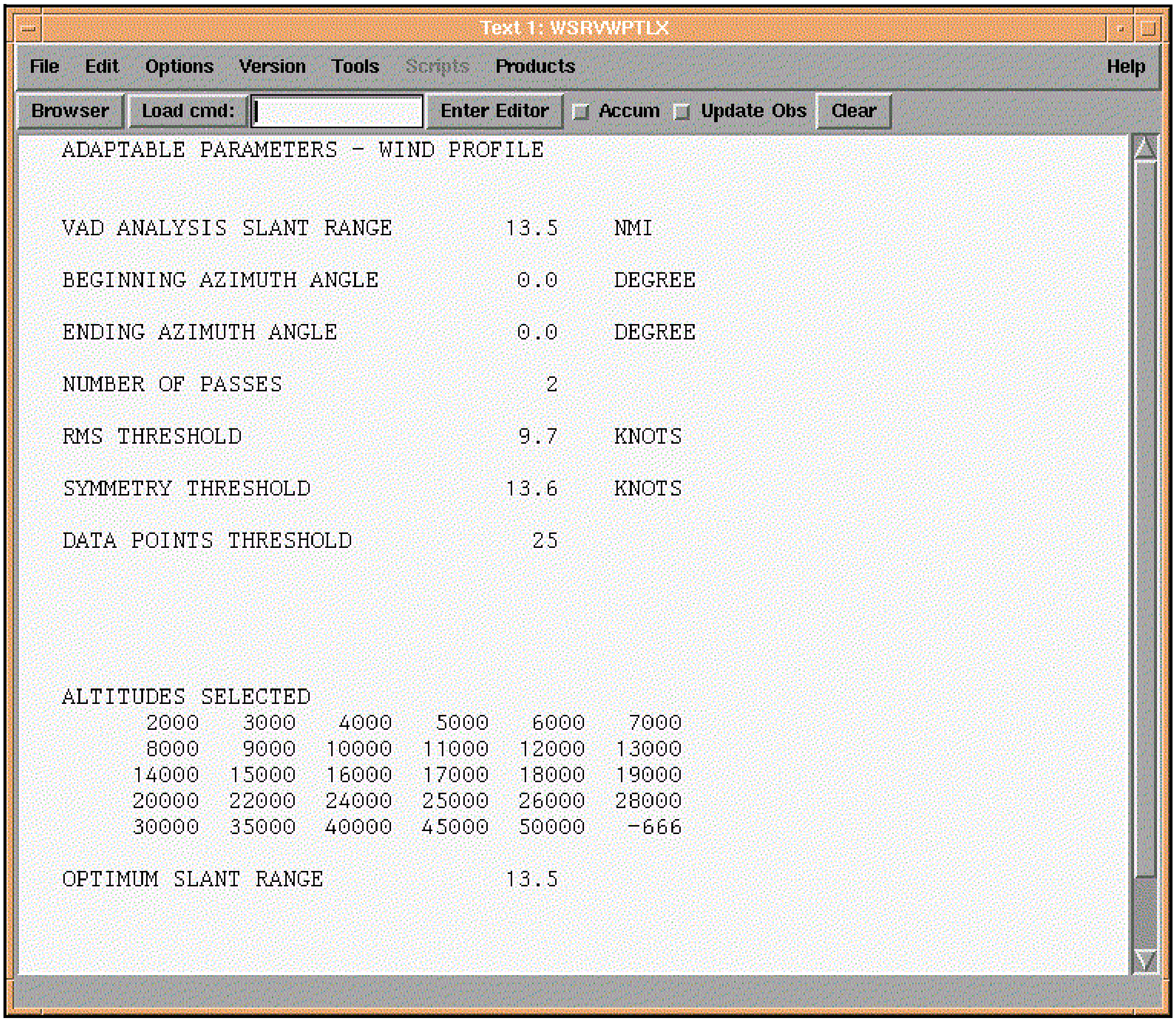


Figure 4-16. VWP adaptable parameters displayed at the AWIPS Text Display Window.

VWP Limitations

1. ***Measurable returns needed -*** at least 25 data points are required on the individual VAD for data to be encoded at that altitude.
2. ***Winds are not encoded if RMS error or symmetry thresholds are exceeded.*** ND will be plotted if RMS exceeds 9.7 kts or symmetry exceeds 13.6 kts.
3. ***Generally only representative of winds within 20 nm of the RDA.***
4. ***Difficult to read wind barbs when north wind barbs and south wind barbs are on successive altitudes.*** Use of the Filter or Blink Functions may help.

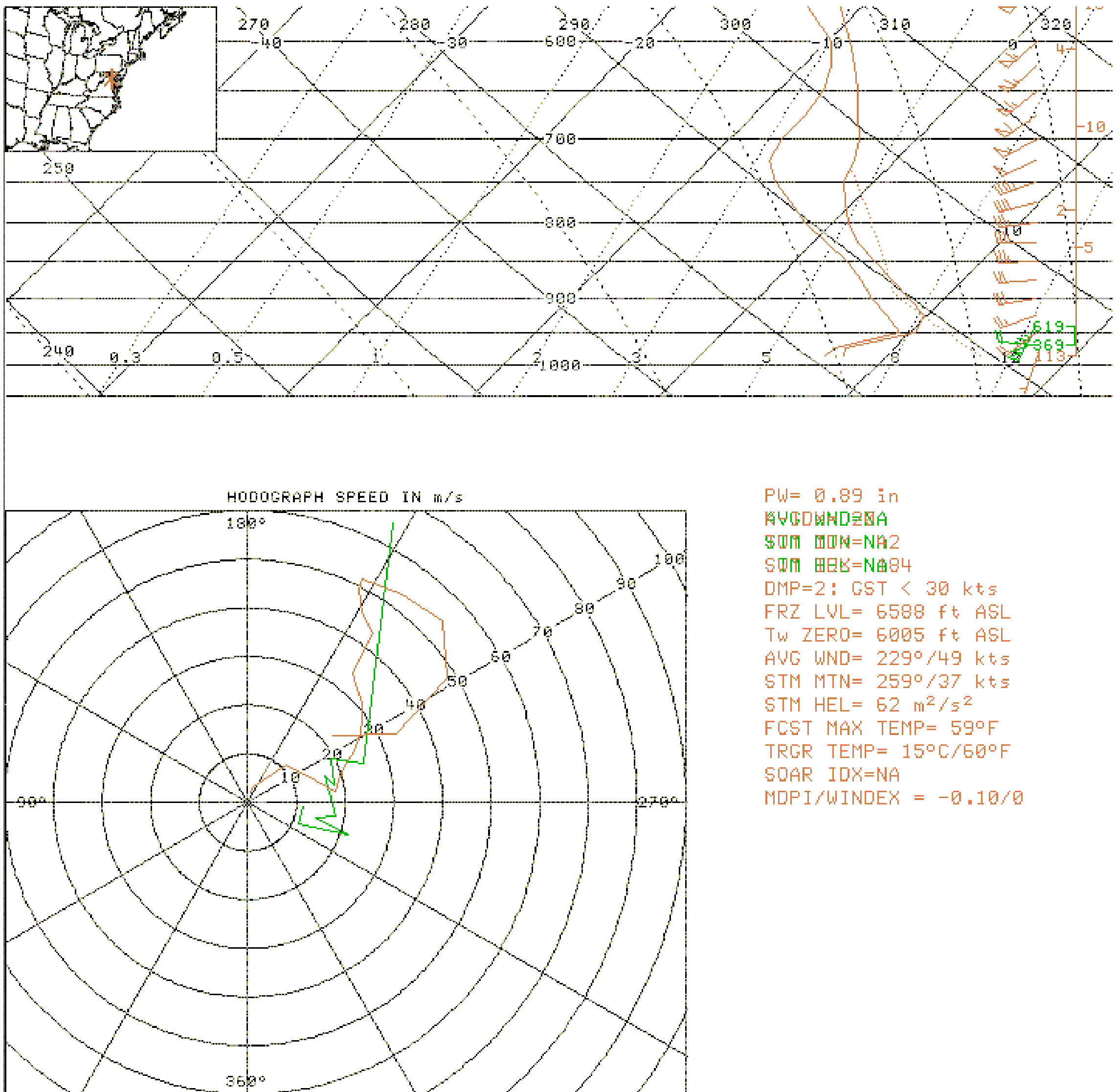


Figure 4-17. VWP hodograph (green) overlaid on Meso-Eta Hodograph (red).

5. ***Birds can produce anomalous wind patterns.*** The usual scenario is an “explosion” of reflectivity coverage and strength as night migrating birds take off. Experts claim that a single Sea Gull can be detected at a range of 460 km. If it is critical to determine the true upper winds, the site should take a supplemental balloon sounding.

VWP Strengths/ Applications

1. The VAD Wind Profile (VWP) may be of assistance in many operations. ***Severe Weather*** operations may benefit as backing or veering of the winds with time display changes in the envi-

ronment. ***Aviation*** operations will be assisted by evidence of wind shear. Low level wind shear may be more visible on VWP than Profilers. ***Hydrology*** and ***Forecasting*** may benefit from indications of the change in the depth of cold air with time, etc. Since sufficient scatterers are often more prevalent in and near clouds, the VWP may be used in estimating cloud tops and bases.

2. ***The VWP can be used to create/adjust hodographs.***

3. ***Future development may include combining the Storm Tracking Algorithm and VAD Wind Profile to output helicity***.

Interim Summary

Velocity Azimuth Display (VAD)

1. A scattering of data points and a fitted sine wave curve are used to compute the winds for individual heights.
2. Product used primarily to check wind data that is "suspect" or missing on the VAD Wind Profile.

VAD Wind Profile (VWP)

1. A composite vertical profile of VAD-derived winds at various levels.
2. Excellent tool for meteorologists in weather forecasting, severe weather, hydrology, and aviation.
3. If fewer than 25 data points exist, or the symmetry or RMS thresholds are exceeded, the VAD Wind Profile will display "ND" (no data) for that height.

Mesocyclone Detection (MD)

Review Of Operator Identified Mesocyclone

Modified NSSL Mesocyclone Definition

- - Small scale rotation closely associated with a convective updraft that meets or exceeds established thresholds for:
  - --Persistence - Minimum of two volume scans
  - --Vertical extent- Shear extends at least 10,000 ft in the vertical
  - ***--Shear*** (See Fig. 4-18)
    - Distance between max inbound and max outbound ≤ 5 nm.
    - *Rotational velocity =* *velocity inbound + velocity outbound* *divided by* 2 (using mid-range values).

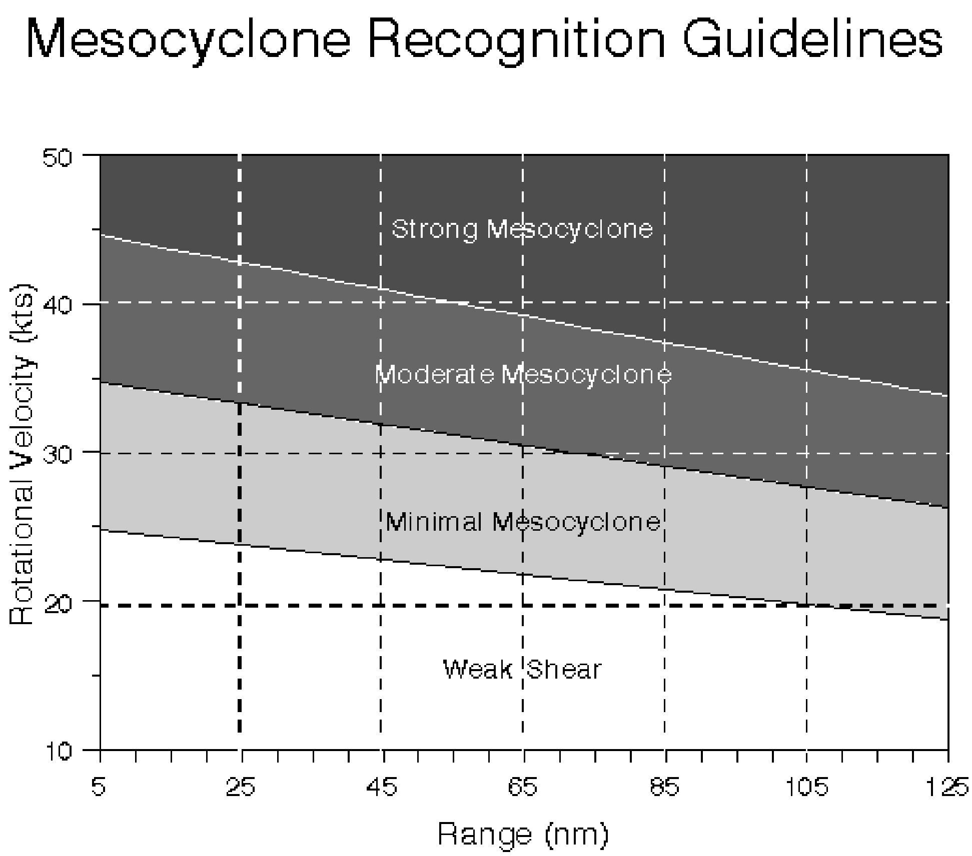


Figure 4-18. Assumes feature diameter of 3.5nm.

Mesocyclone Detection Algorithm (MDA)

Mesocyclone Detection Algorithm (MDA) detects a broad spectrum of circulations and includes tracking (past and future positions) of identified circulations. The Build 6 version of MDA also includes the Digital Mesocyclone Detection (DMD) product, which provides rapid update capability and an extensive attribute table. With OB4 the DMD information is only displayable in SCAN (to be discussed in the DLOC Workshop). More of the DMD information will be displayable in future AWIPS builds.

MDA products (MD, DMD) will not replace the legacy Mesocyclone algorithm products (M, MRU) for several RPG Builds. It is not currently known when the legacy Mesocyclone product will be removed. With Build 6, products from both algorithms will be available. Also, inputs for Alerting, the Radar Coded Message, and the Combined Attribute Table will continue to come from the legacy Mesocyclone algorithm. In this section, we will only discuss products produced by MDA. For additional information on the legacy Mesocyclone algorithm including the Mesocyclone (M) and Mesocyclone Rapid Update (MRU) see the DLOC web site: *http://wdtb.noaa.gov/courses/dloc/index.html*

MDA Products

With RPG Build 6 and AWIPS OB 4.0 two products will be available from MDA:

- Mesocyclone Detection (MD)
    - end of volume scan
- Digital Mesocyclone Detection (DMD)
    - each elevation angle in table format

MDA Processing for a Single Elevation

For a particular elevation angle, MDA searches for shear segments and convergence vectors.

- A shear segment is a string of base velocity bins at a fixed range, where the values increase in a clockwise direction.

- A convergence vector is a string of base velocity bins at a fixed azimuth, where the values decrease in a direction away from the radar.

Minimum Reflectivity

Candidates for shear segments or convergence vectors must have corresponding reflectivity values above a threshold. This threshold is a URC adaptable parameter called the "Minimum Reflectivity". The default setting is 0 dBZ (See Fig. 4-19).

MDA Processing for Multiple Elevation Angles

Shear segments from a single elevation are first combined into 2D features, then checked for strength and aspect ratio. The 2D features are then vertically correlated and initially classified as "circulations". Each circulation is assigned an ID number, with numbers cycling from 0 to 999.

Strength Rank

A Strength Rank value is assigned to each 3D circulation, based on the strengths of the rotational velocities of its associated 2D features. The Strength Ranks range from 1 as the weakest possible to 25 as the strongest. Any circulation with a Strength Rank of 5 or greater is classified as a Mesocyclone.

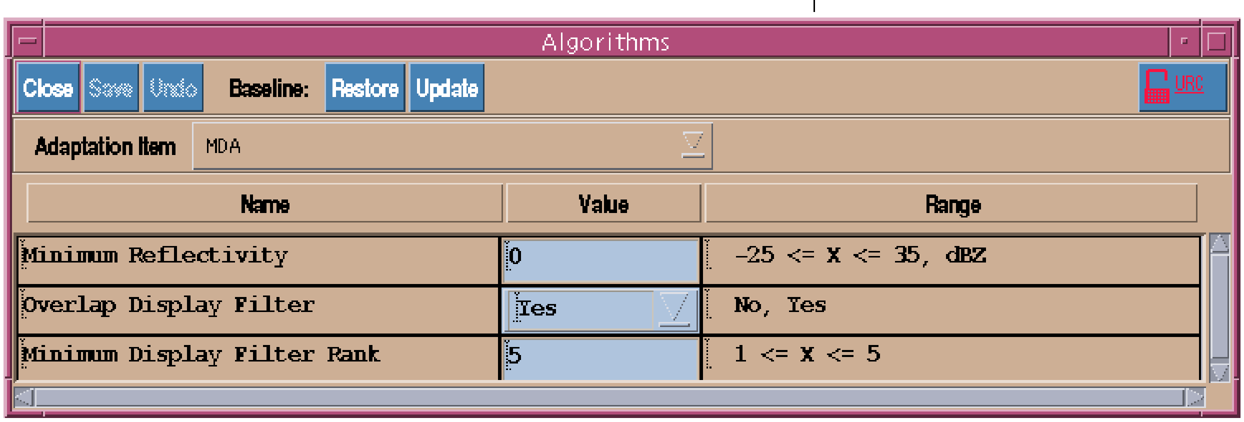


Figure 4-19. MDA Adaptable Parameters at the RPG HCI.

MDA Adaptable Parameters

In addition to the Minimum Reflectivity, there are two other MDA adaptable parameters that are editable.

Minimum Display Filter Rank

The Minimum Display Filter Rank (see Fig. 4-19 on page 123) identifies which circulations are displayed on the end of volume scan MD product. The default setting is 5, which means that all circulations with a Strength Rank of 5 or greater would be displayed on the MD product. If this parameter were set to 5 and the strongest circulation detected had a Strength Rank of 4, ***no*** circulations would be displayed. However, the DMD product would have an entry and will display all circulations, even those with ranks below the Minimum Display Filter Rank.

Overlap Display Filter

This parameter addresses the possibility of two circulations being displayed on a graphical product in the same location, i.e. the circles overlap. If the "Overlap Display Filter" parameter is set to the default value of **Yes** (See Fig. 4-19 on page 123.), the 3D circulation that is detected over lower elevation angles is the one displayed.

Number of Detections vs. Weaker Circulations

Tornadoes are sometimes produced from small, weak circulations. The default setting of 5 for the Minimum Display Filter Rank is based on MDA performance with large, deep supercells. For environments where mini-supercells are favored, setting the Minimum Display Filter Rank to 3 or 4 is a consideration. The smaller circulations will be displayed on the MD product. However, the total number of circulations displayed will increase significantly as the value of this parameter is lowered.

Tracking Features

MDA has a process that attempts to track 3D circulations from one volume scan to the next. At the end of a volume scan, all 3D features are assigned an extrapolated position for the subsequent volume scan based on previous positions. The locations projected from the previous volume scan are then used to try to match to 3D features detected from the current volume scan.

If There is a Match

If a 3D feature is matched for more than one volume scan, the past positions and forecast positions will be displayed. This is very similar to the past and forecast positions for a storm centroid generated by the SCIT algorithm. Past and forecast tracks computed by MDA apply to the 3D feature. Circulations are tracked for up to 10 previous volume scans and up to six forecast positions are computed in 5 minute intervals. The number of forecast positions will never exceed the number of past positions.

Once matched, 3D features will appear on both the MD and DMD products.

If There isn't a Match

A 3D feature from a previous volume scan is retained until there is a match to the subsequent volume scan. However, the search to obtain a match does not persist for the entire volume scan. For a 3D feature detected from a previous volume scan, the search persists until the height of the radar beam is 3 km above the base of the feature. Once the radar beam reaches that height, the feature is removed.

Unmatched features will not be shown on the MD product. They may appear on some elevations of the DMD output while the search for a match is ongoing.

MD Product

The Mesocyclone Detection (MD) product is available at the end of the volume scan. The MD is displayable from the graphics menu (See Fig. 4-20).

Also on this menu are two entries for the Legacy Meso Rapid Update (MRU). The MRU product is based on the ***legacy*** Mesocyclone algorithm information and will not be discussed in this section. The elevation by elevation output from the MDA, which is the Digital Mesocyclone Detection (DMD) product, is displayed from the SCAN menu and discussed at the DLOC workshop.

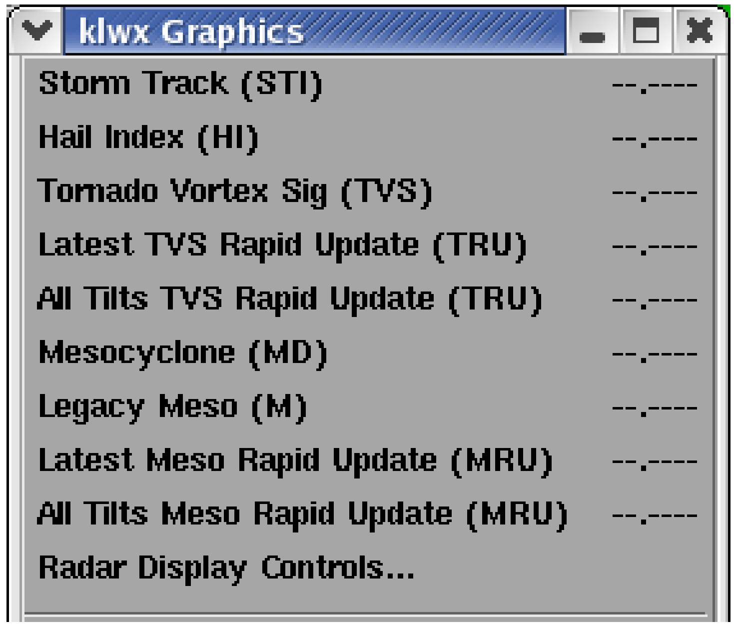


Figure 4-20. Graphics window with entries to display the MD and legacy M and MRU products.

If the MDA adaptable parameters are set to their default values (see Fig. 4-19 on page 123), the MD product will be as similar as possible to the legacy Mesocyclone product ***with respect to which circulations are displayed***. There are other differences between the MD and M products in the additional information that is displayed.

One significant difference is the inclusion of past and forecast tracks provided by the MD product, as long as there are matches from one volume scan to the next.

MD Symbols

There are two symbols (or icons) on the MD product -- a thin yellow circle is used for circulations with a strength rank of 1 through 4, and a thick yellow circle is for circulations with a strength rank of 5 or above. However, if the Minimum Display Filter Rank is set to the default value of 5, thin circles will ***not*** be seen.

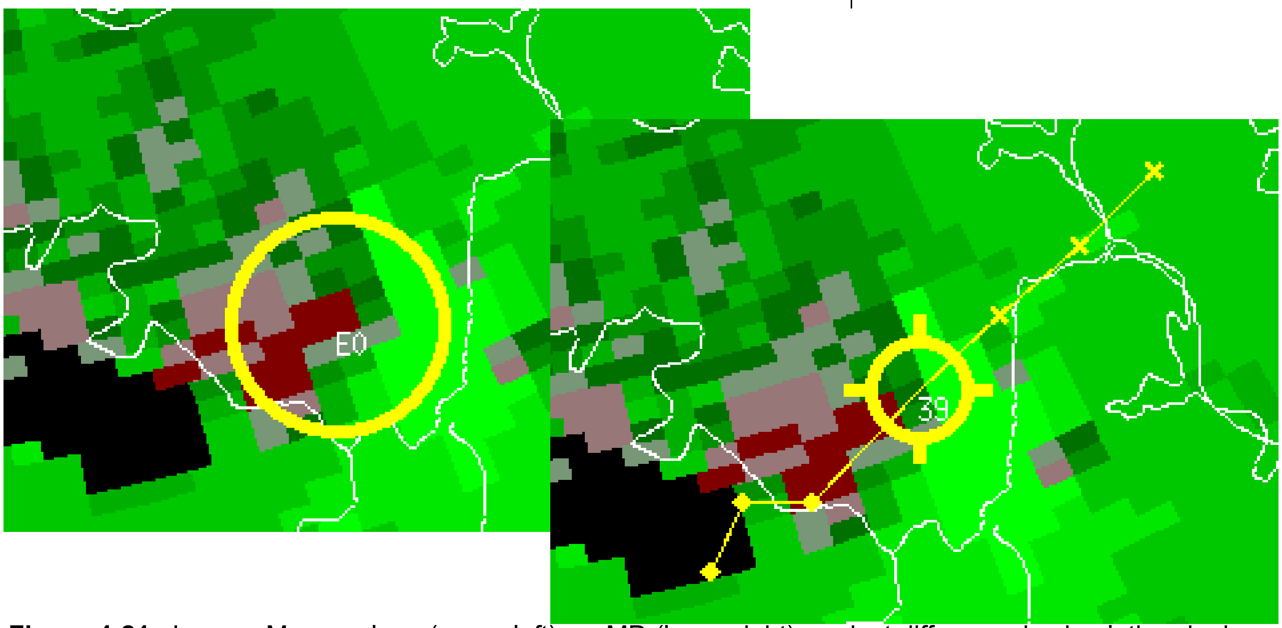


Figure 4-21. Legacy Mesocyclone (upper left) vs. MD (lower right) product difference in circulation depiction.

Assuming the same default setting of 5, if a circulation with a strength rank of 5 or above is detected on the lowest elevation angle (or a base is detected at or below 1 km), four spikes are added to the yellow circle. In Figure 4-21, a low level circulation is depicted on the Legacy Meso product (upper left) and on the MD product (lower right). MDA assigns a 3 digit identification number to each circulation, ranging from 0 to 999. In Figure 4-21 the circulation ID for the MD product (lower right) is 39.

The MD product also has an attribute table at the top of the graphical product, and a text version.

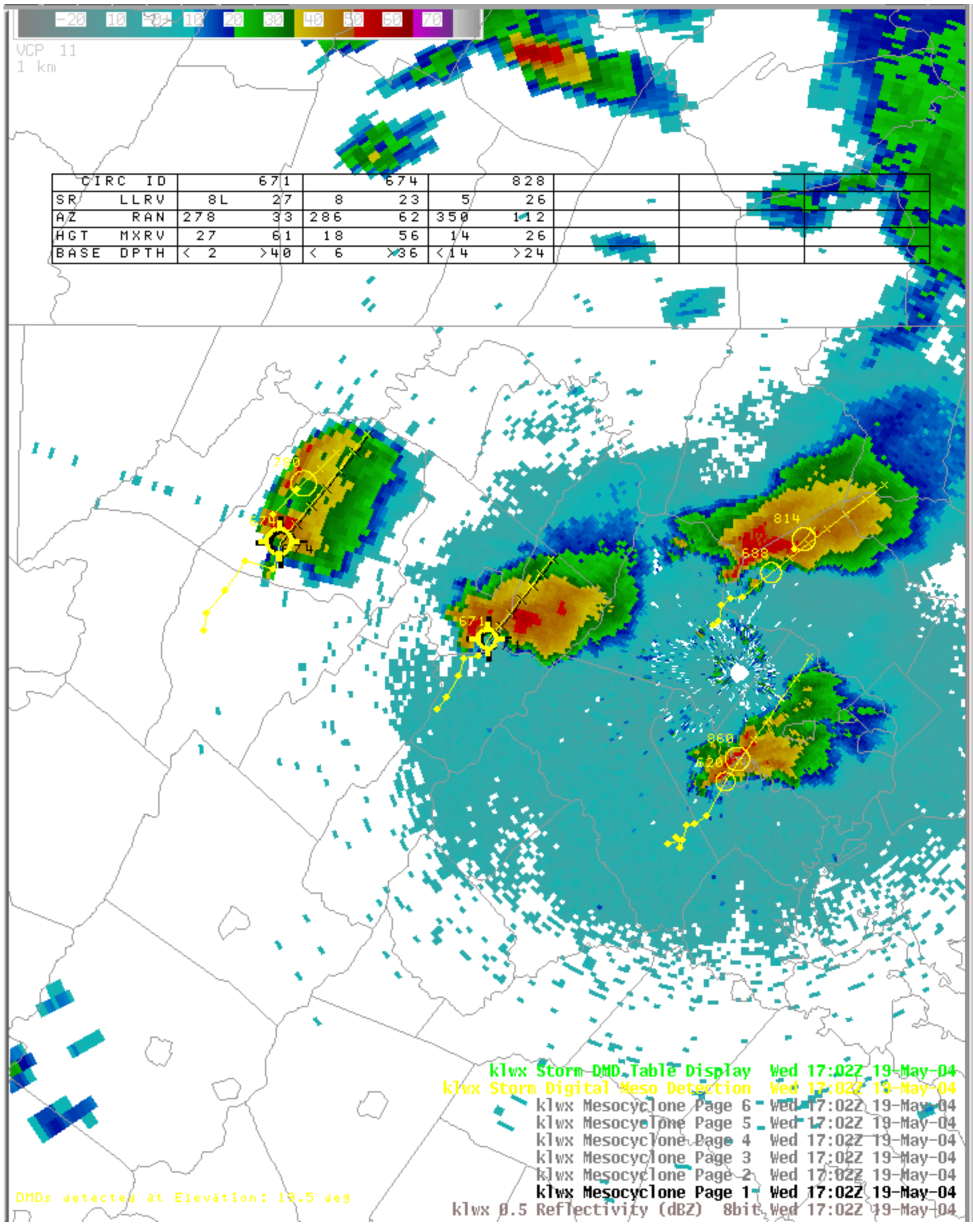


Figure 4-22. MD product overlaid on base reflectivity.

The text version of the MD product is available with AWIPS OB4.0.

Mesocyclone Detection (MD) Product Limitations

1. Does not need 10,000 ft deep circulation. - The algorithm only requires vertically linked 2D circulations.
2. The algorithm only detects cyclonic rotations.
3. Identification is influenced by aspect ratio.

4. Improper dealiasing may generate false mesocyclones.
5. Default settings are for large deep supercells. Changes to adaptable parameters are required for smaller circulations.
6. Numerous detections of circulations may require changes in adaptable parameters.

Mesocyclone Detection (MD) Product Strengths/ Applications

1. Identify mesocyclones - The operator must examine reflectivity, velocity, and SRM to verify existence of mesocyclones.
2. Weak circulations detected.
3. Adaptable parameter changes available to adjust the output to fit the meteorological situation.
4. Tracking attempts to account for time continuity.

Tornadic Vortex Signature (TVS)

Review of Operator Identified TVS

Modified NSSL TVS Definition

An intense gate-to-gate azimuthal shear associated with tornadic-scale rotation. A TVS is identified if the gate-to-gate shear is:

$\geq$ 90 kts and the range is < 30 nm

$\geq$ 70 kts and the range is 30 nm $\leq$ r < 55 nm

Gate-to Gate Shear = Velocity Difference = | velocity inbound | + | velocity outbound |

Remember that these values are only guidelines, the user will have to adjust according to the situation and geographic location.

Tornado Detection Algorithm (TDA)

The Tornado Detection Algorithm (TDA) is designed to detect significant shear regions in the atmosphere. The TDA uses multiple velocity thresholds to locate shear regions, and classifies these regions according to altitude and strength.

The Mesocyclone and Tornado Detection algorithms process data separately. This means that ***an algorithm-identified mesocyclone need not exist for a TVS or Elevated TVS (ETVS) to be identified.*** The TDA is modeled after the SCIT algorithm and uses a three step process to identify circulations.

TDA Process

First, 1-D pattern vectors are identified on each elevation slice. In TDA, a pattern vector is a region of gate-to-gate shear, which means the velocity difference is calculated between range bins ***located on adjacent azimuths*** at the same range. A minimum shear value is required for a pattern vector to be identified (see Fig. 4-23). The TDA searches only for patterns of velocity indicating cyclonic rotation. It ***does not*** detect an anticyclonic signatures.

Next, 2-D features are created by combining the 1-D pattern vectors (see Fig. 4-24). At least three pattern vectors (default) are needed to declare a 2-D feature.

TDA uses six velocity difference thresholds to identify pattern vectors. This technique allows the algorithm to isolate core circulations which may be embedded within regions of long azimuthal shear. An example would be a radially oriented gust front or squall line. In Figure 4-25, a long segment of shear exceeding 15 m/s has embedded within it a smaller segment of shear greater than 20 m/s, and

Range	rad #1	rad #2	rad #3	rad #4	rad #5	rad #6	rad #7
33.00 km	-7	-10	-10	-7	1	2	1
32.75 km	-10	-15	-13	-11	4	3	0
32.50 km	-4	-11	-14	-18	12	22	13
32.25 km	-11	-19	-22	13	18	11	-1
32.00 km	-4	-9	-19	3	13	17	12
31.75 km	-10	-14	-22	1	21	9	9
31.50 km	-10	-25	-19	-6	4	2	1
31.25 km	-7	-3	-5	-6	4	13	10
31.00 km	-1	2	1	-3	-4	-4	-6

Figure 4-23. All increasing velocities (cyclonic shear) are shaded blue. All TDA Pattern Vectors (>11 m/s shear) are shaded pink.

Range	rad #1	rad #2	rad #3	rad #4	rad #5	rad #6	rad #7
33.00 km	-7	-10	-10	-7	1	2	1
32.75 km	-10	-15	-13	-11	4	3	0
32.50 km	-4	-11	-14	-18	12	22	13
32.25 km	-11	-19	-22	13	18	11	-1
32.00 km	-4	-9	-19	3	13	17	12
31.75 km	-10	-14	-22	1	21	9	9
31.50 km	-10	-25	-19	-6	4	2	1
31.25 km	-7	-3	-5	-6	4	13	10
31.00 km	-1	2	1	-3	-4	-4	-6

Not Included

Figure 4-24. 2-D Feature outlined in yellow.

still smaller segments of shear greater than 25 m/s. If a 2-D feature passes a symmetry test (length to width ratio within a specified limit), it is declared a 2-D circulation.

Finally, 3-D features are created by vertically correlating the 2-D circulations identified at each ele-

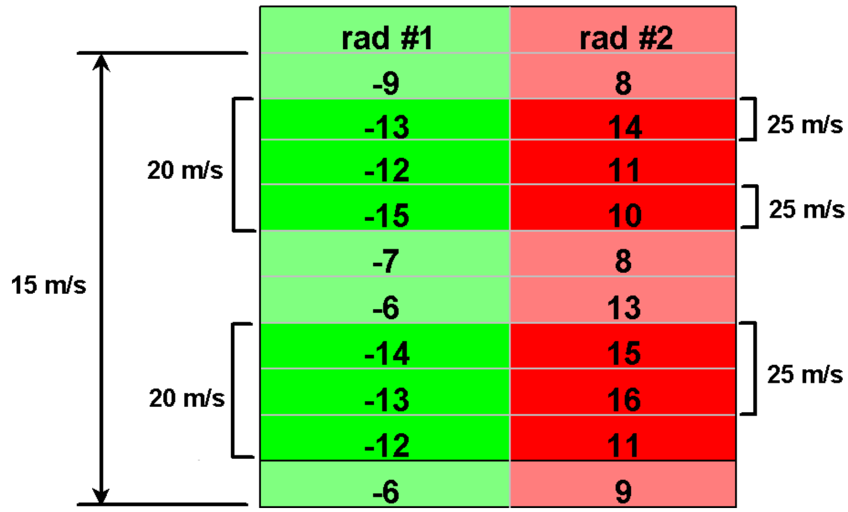


Figure 4-25. 2-D Features - Multiple velocity thresholds used to identify stronger shear embedded within weaker shear.

vation (see Fig. 4-26). Processing begins by correlating the strongest 2-D circulations first, then moving to progressively weaker circulations. If a feature contains at least three vertically correlated 2-D circulations, it is declared a 3-D circulation, and identified as either a TVS or an ETVS. Ideally, there will be no gaps in elevation angles between the vertically correlated 2-D circulations. However, a one elevation angle gap is permitted to account for base data problems such as range folding and velocity dealiasing failures.

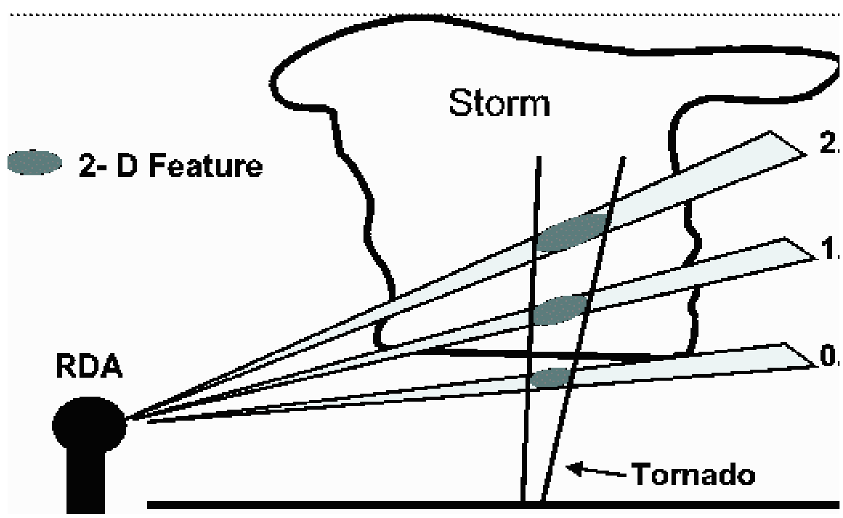


Figure 4-26. Vertically correlated 2-D circulations.

TDA Adaptable Parameters

There are a number of TDA adaptable parameters. Six of these parameters ar under URC Level of Change Authority. A more in-depth look at these adaptable parameters is available in the RPG Adaptable Parameters Handbook Section 6.15 (http://www.roc.noaa.gov/ssb/sysdoc/manuals/Operations_TMS/AporpgSCR1.pdf).

Three of the adaptable parameters are changed as a set (default value in parenthesis):

- Minimum 3D Feature Depth (1.5 km)
- Minimum Low Level Delta Velocity (25 m/s
- Minimum TVS Delta Velocity (36 m/s)

The other three can be set independently based on URC preference:

- Minimum Reflectivity (0 dBZ)
- Maximum Pattern Vector Range (100 km)
- Maximum Number of ETVSs (0)

Definitions and Symbology

TVS

A Tornadic Vortex Signature, TVS, is defined as a 3-D circulation with a base located on the 0.5° slice ***or*** below 600 meters ARL (above radar level). The depth of the circulation, maximum delta velocity anywhere in the circulation, and the delta velocity at the base of the circulation must exceed the adaptable parameters set (see previous section). The TVS symbol is displayed on the graphic product and overlay as a red, filled, inverted triangle. TVS symbols are placed at the azimuth and range of the lowest 2-D feature.

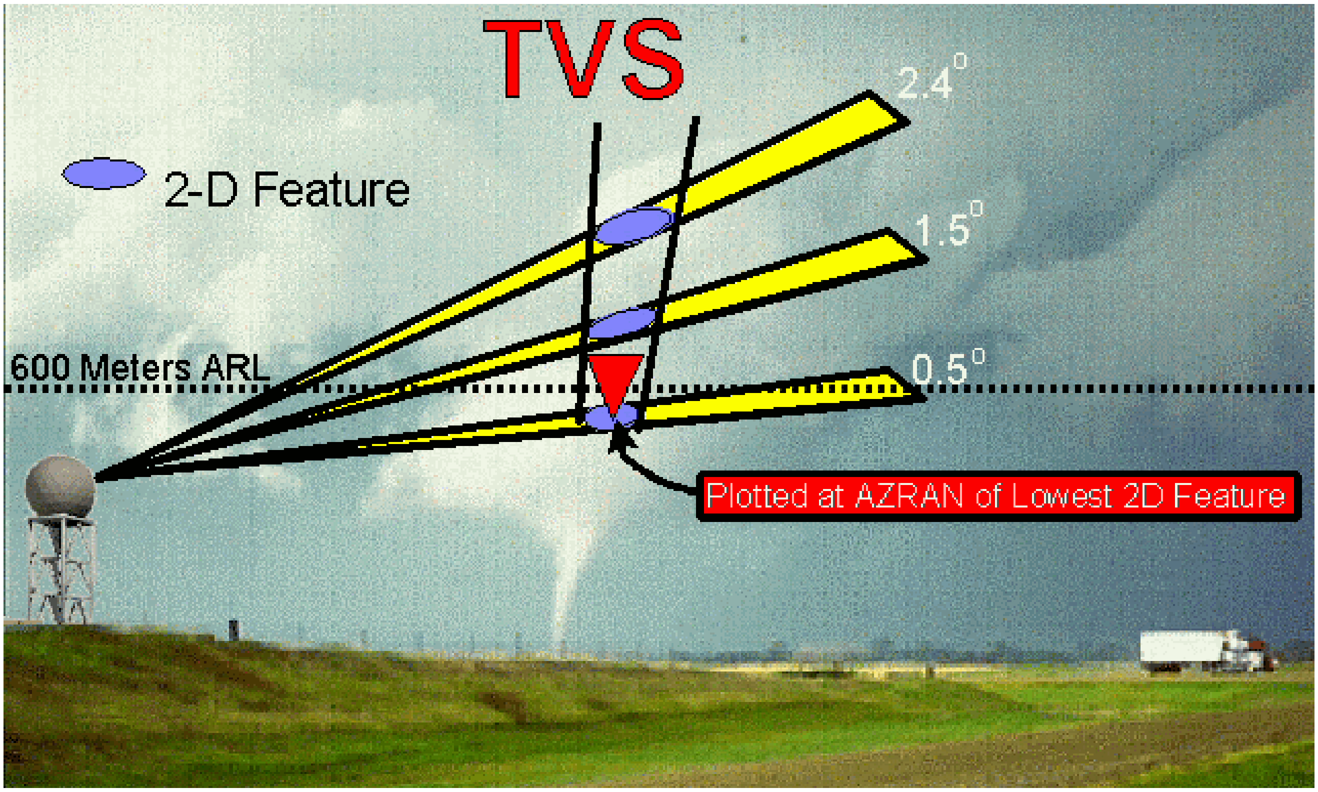


Figure 4-27. TVS definition.

ETVS

An Elevated Tornadic Vortex Signature, Elevated TVS or ETVS, is defined as a 3-D circulation with a base above the 0.5° slice ***and*** above 600 meters ARL. The depth of the circulation must be at least 1.5 km. Additionally, the thresholds of depth, max delta velocity and low level delta velocity must be exceeded. The ETVS symbol is displayed on the TVS overlay and the TVS graphic product as a red, open, inverted triangle as shown in Figure 4-29, and is placed at the azimuth and range of the lowest 2-D feature

Note that an Elevated TVS may possess a larger value of maximum shear somewhere in the storm column as compared to a TVS, but if there is no circulation on the 0.5° slice or below 600 meters, it cannot be defined as a TVS, despite possessing the higher shear.

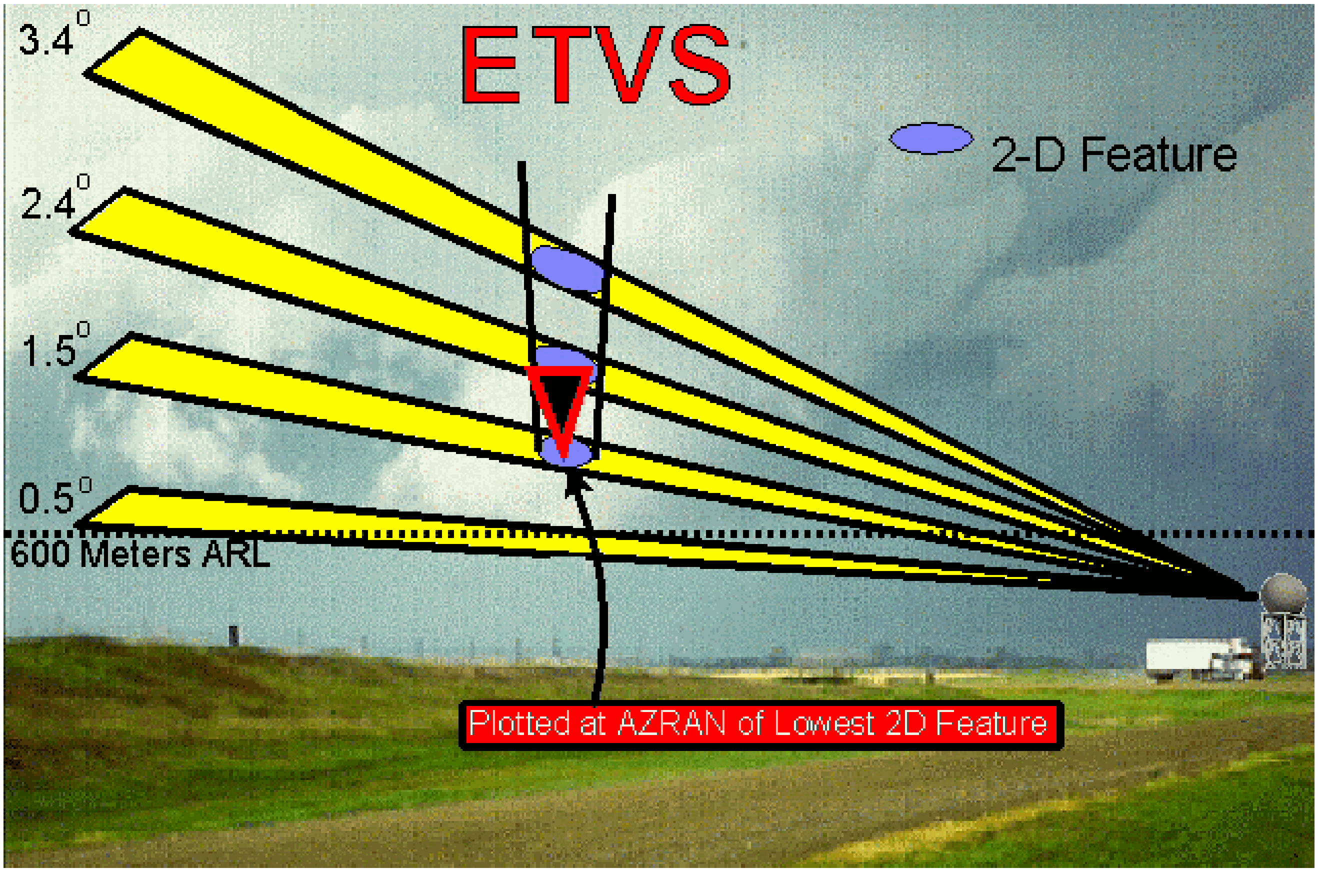


Figure 4-28. ETVS definition.

TVS Product Parameters

See Figure 4-29 for an example of the TVS product

TVS product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Tornado Vortex Signature
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

TVS product annotations

- TVS Attribute Table

Additional TVS product characteristics

- RANGE: 124 nm

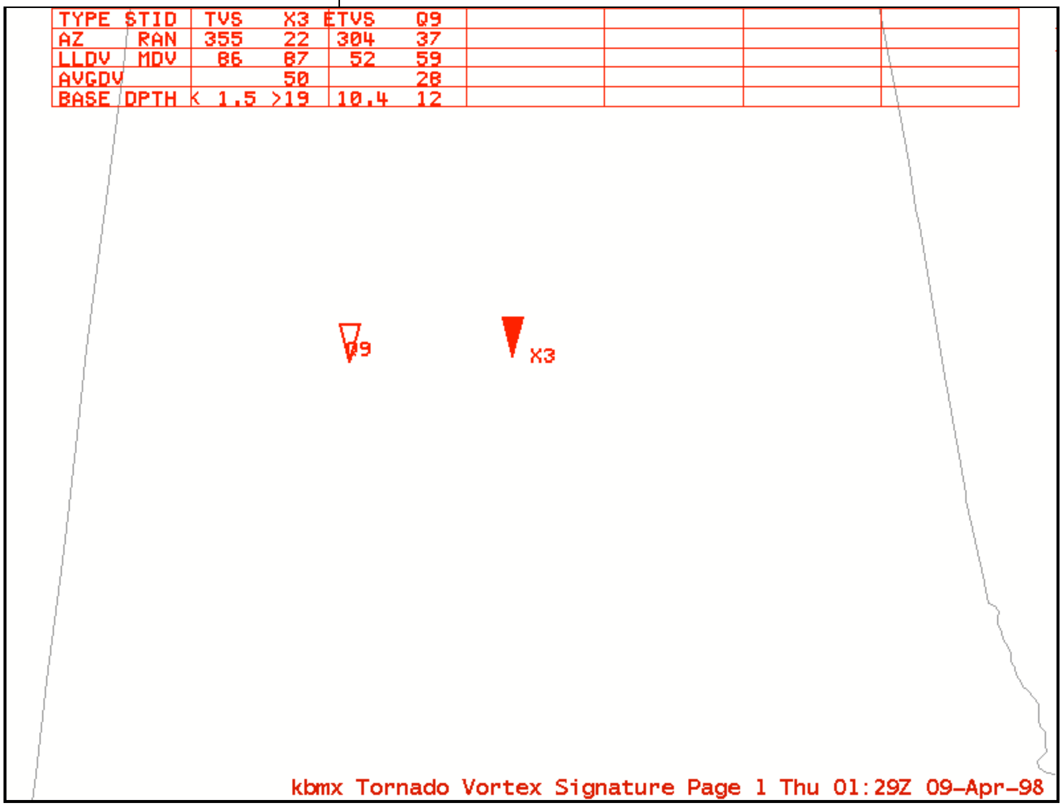


Figure 4-29. Example of TVS graphic product.

TVS Attribute Table

The TVS Attribute Table is available if any TVSs or ETVSs are detected. See Figure 4-30.

TYPE	STID	TVS	X3	ETVS	Q9
AZ	RAN	355	22	304	37
LLDV	MDV	86	87	52	59
AVGDV			50		28
BASE	DPTH	<1.5	>19	10.4	12

Figure 4-30. TVS Attribute Table which appears at the top of the TVS product.

Definitions

- **LLDV**: Low-Level Delta Velocity, in knots (Greatest velocity difference of lowest 2-D circulation)
- **MDV**: Maximum Delta Velocity, in knots (Greatest velocity difference of any 2-D circulation)

- **AVGDV**: Average Delta Velocity, in knots (Average weighted velocity difference of all 2-D circulations)
- **BASE**: Lowest altitude of the 3-D circulation, in Kft (Altitude of the lowest 2-D circulation)
- **DPTH**: Depth of the 3-D circulation, in Kft (Height difference between the lowest and highest 2-D circulation)

If a circulation exists at either 0.5° or 19.5°, then the depth of the circulation (DPTH) is estimated, and a > (greater than) symbol will be displayed with the stated depth. Similarly, if the circulation exists at 0.5°, the base (BASE) of the circulation is estimated, and a < (less than) symbol will be used with the stated base altitude. (See Figure 4-29)

TVS Alphanumeric Product

The TVS Adaptation Data can be displayed at the AWIPS Text Display Window (WSRTVSxxx). This can be used to determine the adaptable parameter settings used to generate the product. See Figure 4-31.

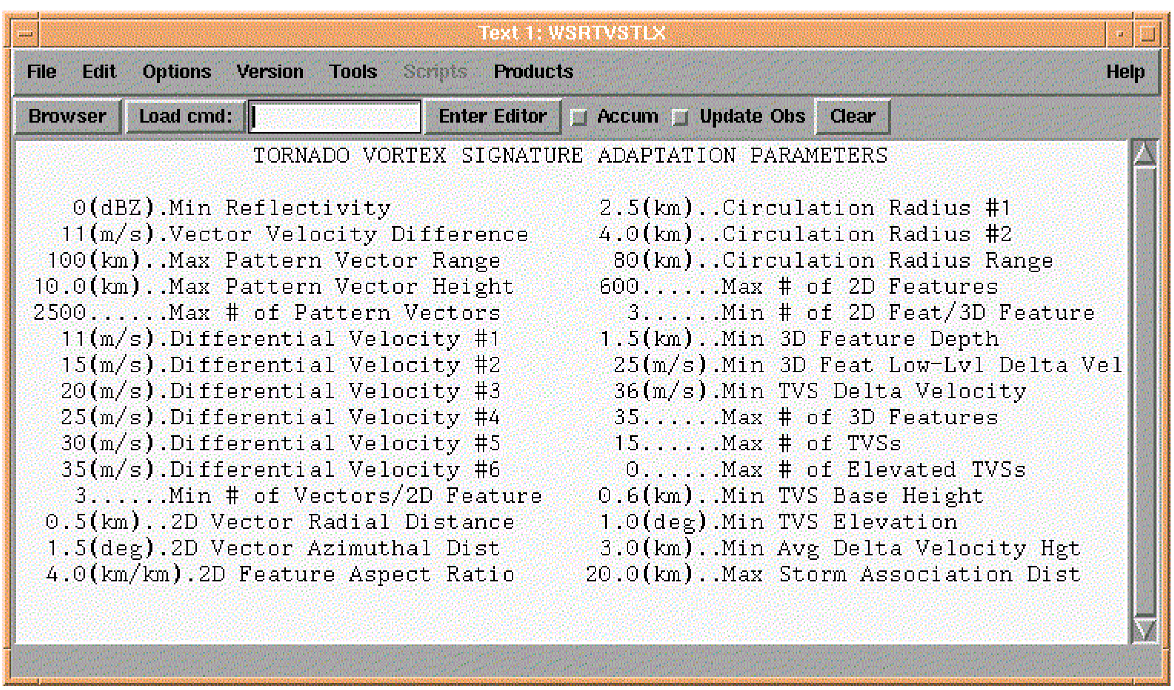


Figure 4-31. TVS adaptable parameters displayed at the AWIPS Text Display Window.

Radar Display Controls (ETVS Display Toggle)

Depending on which adaptable parameter settings are invoked, it is possible to have a situation when the display becomes cluttered with Elevated TVS symbols, making product interpretation difficult. For this reason, operators have been given control over whether or not ETVS symbols are displayed on the TVS graphic product and overlay.

This toggle does not affect the TVS attribute table or the TVS alphanumeric product or other AWIPS workstations. It is a graphic display function only. If the ETVS symbol is toggled to “off”, a situation could arise where outside users are getting ETVSs, but the AWIPS graphic product is not displaying this information.

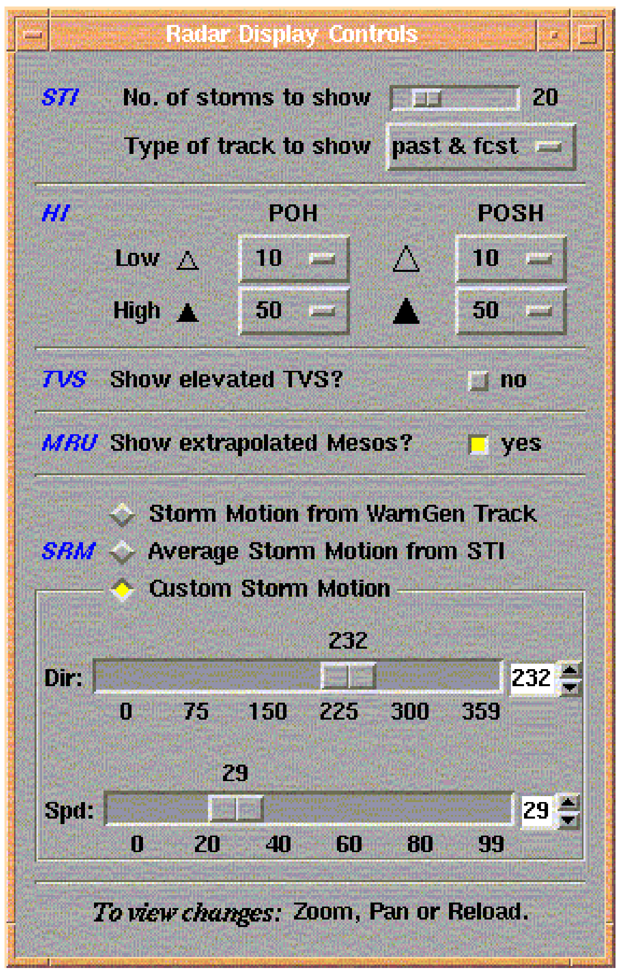


Figure 4-32. Radar Display Controls Edit Screen.

Operational Considerations

When a TVS detection occurs, consider the environmental wind and thermal profile, the signatures position in relation to the storm with which it is associated, time continuity, and the storm's range from the radar. Beyond about 60 km, the TVS will most likely be triggered by a strong mesocyclone and not all mesocyclones produce a tornado. Since the TDA works independently of the mesocyclone algorithm, the detection of a mesocyclone coincident with the TVS may support issuing a tornado warning. If the TVS is adjacent to a strong reflectivity gradient especially near the back of a storm, near a notch on the right rear flank of a storm, or near the tip of an appendage attached to the right rear flank of a storm, then the forecaster should give greater consideration to issuing a tornado warning.

Because of its sensitivity, the TDA shows continuity in time and space. TVS detections for the same storm on two or more consecutive volumes can suggest the validity of issuing a tornado warning. The TDA has identified TVSs nearly continuously on long-lived supercells typical of the Great Plains, especially ones that cyclically produce tornadoes. In the South and the Southeast, tornadoes may be embedded within squall lines. The TDA tends to identify TVSs near the bend in a line echo wave pattern along the interface between warm moist inflow and storm outflow. While many of the TVSs are false alarms, tornadoes do occasionally spin up under these conditions.

Elevated TVSs are routinely generated by the TDA, but naturally do not score statistically as well as TVSs. However, ETVSs may be used as indicators of rotation aloft that could, with sufficient vorticity near the ground, produce a tornado. That is, they can be used to provide better lead times for identifying storms with the potential to produce tornadoes. A second use is to fill in gaps in TVS detections. Sometimes vertical continuity cannot be established between the lowest elevation and higher elevations. Other times ground clutter or range folding precludes measuring high gate-to-gate velocity differences. An elevated TVS may provide the time continuity to give a forecaster confidence to issue a tornado warning. ***One should be cautious about issuing a tornado warning based solely on ETVSs.***

Remember that algorithms serve to provide users with guidance. Ultimately, the decision to issue or not to issue a warning is up to the individual forecaster using all available data, including spotter reports.

TVS Limitations

1. **Adaptable parameters need more research.** Parameters which work well in one type of meteorological setting may not be as effective in other situations.
2. **High false alarm rates especially in squall lines and tropical cyclones.** A high FAR with TDA may result in over-warning, or desensitizing forecasters.
3. **Little research has been done to date relating the occurrence of tornadoes to Elevated TVSs.** Forecasters should use ETVS output with caution until they develop a better understanding of its utility.

TVS Strengths/Applications

1. The algorithm searches for gate-to-gate shear, which is related to tornadic circulations.
2. Multiple velocity-difference thresholds make it possible to isolate small regions of shear within broader regions.

3. A distinction is made between different types of shears (TVS vs. ETVS, delta velocity calculations), and more information is provided about the base and depth of circulations.
4. The algorithm, through a large number of adaptable parameters, allows fine-tuning of algorithm performance, resulting in a higher probability of detecting operationally important shear regions.

TVS Rapid Update (TRU)

The TVS Rapid Update (TRU) generates a product for each elevation angle (in Precipitation Mode) through a volume scan using the results of the Tornado Detection Algorithm (TDA).

The TRU products closely resembles the format of the TVS product but with the following differences:

- In the graphic attributes table (see Fig. 4-33) and the tabular alphanumeric product (see Fig. 4-34 on page 142), the symbol **^** will be next to data that is updated with respect to previous volume scan data
- The graphically displayed icons will distinguish between **extrapolated** and current TVS and ETVS features (see Fig. 4-35 on page 142).

TYPE STID	TVS B2	ETVS ^ C0	ETVS ^ B2	ETVS ^ U2	ETVS ^ U2	ETVS ^ G2
AZ RAN	307 54	294 ^ 30	301 ^ 50	281 ^ 30	286 ^ 29	338 ^ 45
LLDV MDV	57 57	^ 61 ^ 82	^ 59 ^ 84	^ 58 ^ 58	^ 52 ^ 52	^ 51 ^ 56
STA AVGDV	EXT 34	NEW ^ 16	NEW ^ 31	NEW ^ 19	NEW ^ 21	NEW ^ 17
BASE DPTH	7.1 8	16.7^ 14	8.4^ 21	16.8^ 9	13.1^ 12	16.2^ 15

Figure 4-33. TRU Attributes Table.

TRU Graphical Product

The TRU graphical product uses traditional TVS (filled in red triangle) and ETVS (open red triangle) symbols. For extrapolated (detection from previ-

TVS Rapid Update

RADAR ID: 302 DATE: 05/09/2003 TIME: 23:58:42 TVS/ETVS: 1/ 6 ELEV: 15.6

FEATURE STA TYPE	STORM ID	AZ/RAN (deg,nm)	AVGDV (kt)	LLDV (kt)	MXDV/Hgt (kt,kft)	Depth (kft)	Base/Top (kft)	MXSHR/Hgt (E-3/s,kft)
EXT TVS	B2	307/ 54	34	57	57/ 7.1	8.5	7.1/ 15.5	17/ 7.1
NEW ETVS^	C0	294/ 30^	16^	61^	82/30.7^	14.1^	16.7/ 30.7^	46/30.7^
NEW ETVS^	B2	301/ 50^	31^	59^	84/23.6^	21.2^	8.4/ 29.6^	26/23.6^
NEW ETVS^	U2	281/ 30^	19^	58^	58/16.8^	8.7^	16.8/ 25.5^	31/16.8^
NEW ETVS^	U2	286/ 29^	21^	52^	52/13.1^	12.4^	13.1/ 25.5^	28/13.1^
NEW ETVS^	G2	338/ 45^	17^	51^	56/20.9^	15.2^	16.2/ 31.4^	20/20.9^
NEW ETVS^	C0	292/ 28^	18^	50^	50/15.6^	7.9^	15.6/ 23.5^	28/15.6^

Figure 4-34. TRU Alphanumeric Product.

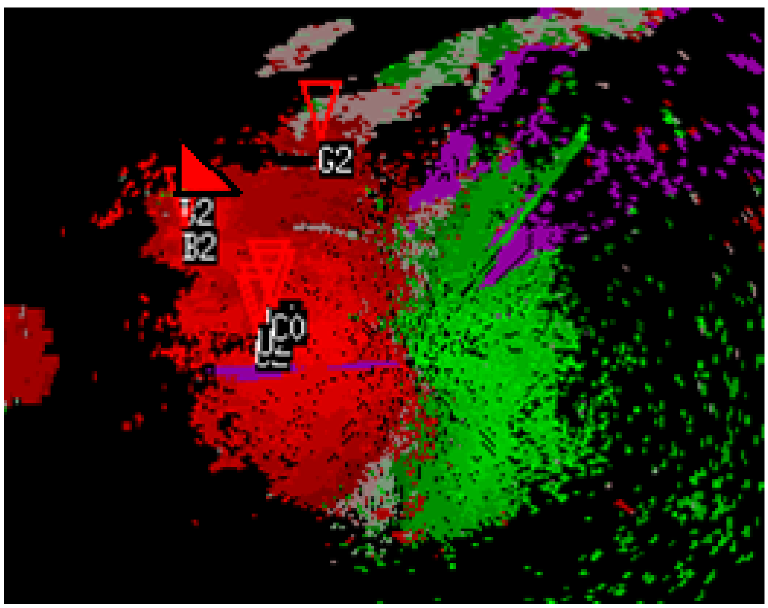


Figure 4-35. TRU Graphic Product. Note the extrapolated (unmatched) detection associated with cell B2 that is annotated with a filled right triangle.

ous volume scan unmatched to current volume scan) detection a filled right triangle is used.

Matching Features

All features (TVS and ETVS) identified on the previous volume scan are projected to move at the average motion of all cells identified by the SCIT algorithm. Until a match is made with a feature on the current volume scan, the feature is marked as **extrapolated** (filled right triangle on the graphic product). If a match is not made within a search radius (default 10 km) by the end of the volume scan, the EXT feature is dropped.

If there is a match

If there is a match, the current feature initially inherits the attributes of the previous feature. These attributes include:

- associated storm id
- feature type (TVS or ETVS)
- low-level delta velocity (LLDV)
- maximum delta velocity (MDV)
- average delta velocity (AVGDV)
- maximum shear
- height, base and top heights, depth

The position attributes base azimuth, range and height are updated to the current detection.

Increasing or Persistent

A feature on the current volume scan that can be matched to a feature on the previous volume scan are categorized as **INC** (increasing) or **PER** (persistent) based on whether there is an increase in any of the “strength attributes”:

- feature type (TVS or ETVS)
- low-level delta velocity (LLDV)
- depth

If none of the “strength attributes” increase, the feature is assigned the status PER (persistent).(See Fig. 4-36 on page 144.)

Requesting TRU

The AWIPS user can request the TRU product via RPS list or one-time requests. A request can be made at one or several elevation angles. The elevation angle field in the product request message

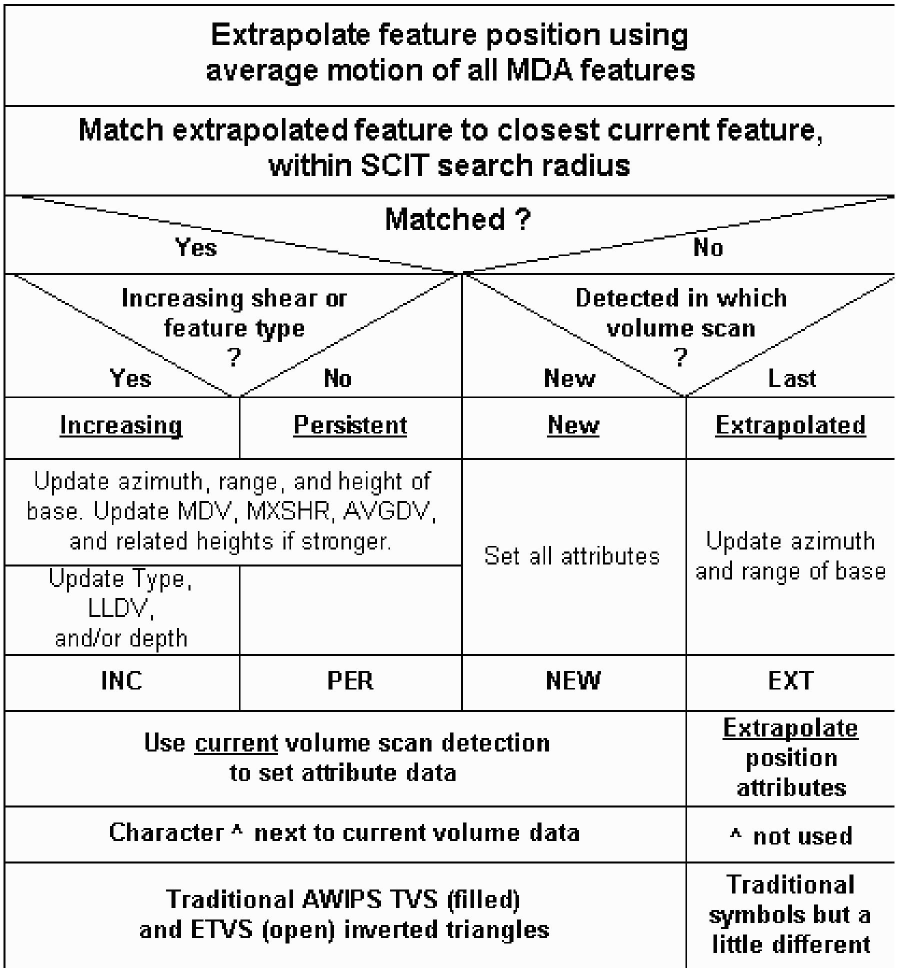


Figure 4-36. TRU Matching Process. There are four types of detections on the TRU: **INC** (increasing), **PER** (persistent), **NEW** (new), and **EXT** (extrapolated).

can be used to specify an elevation angle (e.g., send me the TRU at the end of the 1.5 degree cut), or how many of the lowest scans below a specific angle (e.g., send me all elevations below 5 degrees elevation), or to provide all elevation scans (i.e., send me a TRU at the end of each elevation scan).

TRU Product Limitations

1. Classification as INC (increasing) or (PER) persistent may be the result of sampling issues versus an actual change of the feature.

2. The TRU graphical attribute table and alphanumeric product contain attributes from both the previous and current volume scan.
   - Pay particular attention to the **^** symbol that indicates the attribute is from the current volume scan.
3. Feature matching ability is dependent on the motion supplied by the SCIT algorithm.

TRU Product Applications (Strengths)

1. Intermediate Tornado Detection Algorithm (TDA) is available before end of volume scan.
2. TRU tracks features to develop time continuity.

Interim Summary

Mesocyclone Detection (MD) Product

1. Detections on the MD product must be investigated for validity using Base Velocity or SRM.
2. If a mesocyclone is detected in the velocity field before the algorithm, don't wait for a mesocyclone symbol from the algorithm to take the appropriate action.
3. Adaptable parameters will need to be adjusted to various meteorological situations.

TVS Product

1. The TVS product can be useful in alerting the operator of significant and possibly tornadic circulations.
2. Many TVS detections (especially in squall line and tropical cyclone situations do not produce tornadoes.

TVS Rapid Update

1. Output from TDA algorithm available at each elevation scan, allowing operator to view output before end of volume scan.
2. Feature matching dependent on motion supplied by SCIT algorithm.

Lesson 5: Precipitation Algorithms and Products

This lesson will present the precipitation products generated by the WSR-88D, and the algorithms which produce them.

It is important for operators to have a basic understanding of the precipitation algorithms and how they affect the WSR-88D precipitation products.

Objectives

Without references, in accordance with standardized instruction, you will be able to:

a. Identify the limitations and applications/strengths of the Precipitation Processing Subsystem.

b. Describe the precipitation products produced by the Precipitation Processing Subsystem.

c. Identify the limitations and applications/strengths of the Precipitation products.

Precipitation Processing Subsystem (PPS)

The precipitation algorithms commonly called the Precipitation Processing Subsystem (PPS) contain numerous quality control steps. Since radar only indirectly measures precipitation rates, extensive quality control is applied to get the best possible rainfall estimates.

Because of the quality control steps used in the PPS, the operator will notice a difference between the reflectivity data used as input and the corresponding precipitation products.

Rainfall estimates are only provided out to 124 nm. No estimates are generated beyond 124 nm because errors increase rapidly beyond that range.

The algorithms in the PPS are highly flexible with many adaptable parameters. The process of tailoring adaptable parameters for each radar site requires research and observations from the field users of the system. Changes in most adaptable parameter settings requires coordination with the ROC and the Office of Hydrology.

Overview

For completeness we will first discuss the Precipitation Detection Function. While this function no longer directly impacts the PPS, it is still important to understand its impact on VCP selection.

The four algorithms of the PPS are discussed in this section:

1. Enhanced Precipitation Preprocessing (EPRE)

2. Precipitation Rate

3. Precipitation Accumulation

4. Precipitation Adjustment

Precipitation Detection Function (PDF)

With the introduction of the Enhanced Precipitation Preprocessing in RPG Build 5, the only functions of the Precipitation Detection Function (PDF) are to:

1. determine when the radar automatically switches from Clear Air Mode (VCPs 31 and 32) to Precipitation Mode (default VCP 21), and
2. when the operator can change from Precipitation Mode (VCP 11, 12, 21, and 121) to Clear Air Mode (VCPs 31 and 32).

The PDF **does not** determine when precipitation is accumulated in the precipitation products. Beginning in RPG Build 5, this determination is made by the Enhanced Precipitation Preprocessing (EPRE) algorithm.

Process

Each volume scan the PDF compares Base Reflectivity data on the lowest four elevation angles to specific thresholds. The three thresholds used by the PDF are:

- *Precipitation Rate Threshold* (in dBR) - This is echo intensity. This threshold is **not** editable by the operator.At the RPG HCI, the units are in dB of rainfall rate. For better understanding, we can convert dBR to dBZ equivalent:
  - Category 2: -2 dBR is equivalent to 22 dBZ,
  - Category 1: 4 dBR is equivalent to 30 dBZ.
- *Precipitation Area Threshold* (in km^2) - This is the allowable areal coverage of precipitation-like return without activating the precipitation algorithms. This threshold is **not** editable by the operator.
- *Nominal Clutter Area (NCA) Threshold* (in km^2) - This value is to be used to account for ***residual clutter*** contamination whose reflectivity exceeds the precipitation rate threshold. This value ***is*** editable.

Precipitation Categories Assigned

Based on whether the intensity **and** areal coverage of the precipitation exceeds the Precipitation Rate Threshold **and** Area Threshold (the sum of the Precipitation Area Threshold and Nominal Clutter Area), one of three precipitation categories is assigned:

- Category 0 - no precipitation,
- Category 1 - significant precipitation, or
- Category 2 - light precipitation

Impacts

If category 0 or category 2 is detected for one hour or longer, and the radar is in a Precipitation Mode VCP (11, 12, 21, or 121), then the **operator has the option to switch** to a Clear Air Mode VCP (31 or 32). If the radar is already in a Clear Air Mode VCP, it will remain in that VCP.

If category 1 is detected, and the radar is in a Clear Air Mode VCP, the radar will **automatically switch** to Precipitation Mode (default VCP 21).

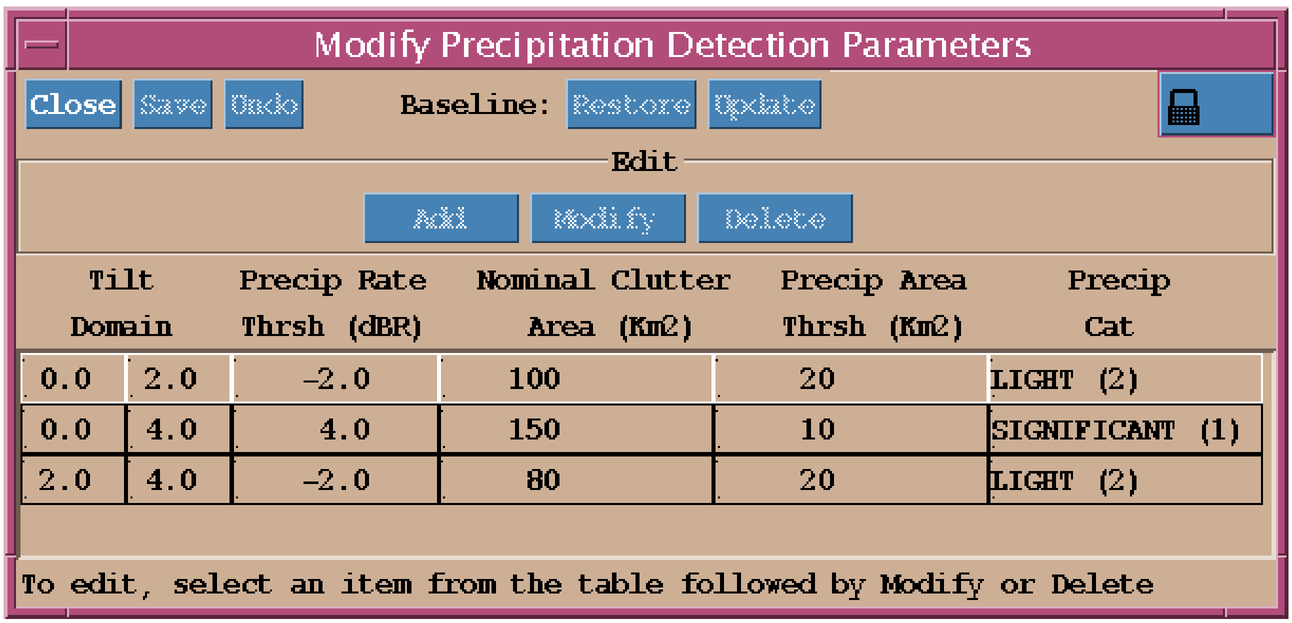


Figure 5-1. Precipitation Detection Function screen at the RPG HCI. The Nominal Clutter Area should be used to account for the areal coverage of residual clutter.

Clear Air and Precipitation Detection

At times, such as a snow event, Clear Air mode reflectivity data may be desired. VCPs 31 or 32 are more sensitive and display lower reflectivities (down to -28 dBZ). Raising the Nominal Clutter Area for category 1 will allow the operator to run the radar in VCPs 31 or 32 with larger areas of high (above 30 dBZ) reflectivities.

This method must be used with care however. The potential exists for significant storms to develop, without the automatic switch to VCP 21. Recall that the Clear Air Mode VCPs volume scan times are 10 minutes. In convective situations, the volume scan times of 4 to 6 minutes are often critically important.

Enhanced Precipitation Preprocessing (EPRE)

The Enhanced Precipitation Preprocessing Algorithm (EPRE) replaced the legacy Precipitation Preprocessing Algorithm in RPG Build 5. The principal reasons for implementing the EPRE algorithm were to allow for precipitation processing with the new VCPs (12 and 121) and to update some of the legacy preprocessing logic. This new logic considers terrain blockage and clutter contamination on a point by point basis.

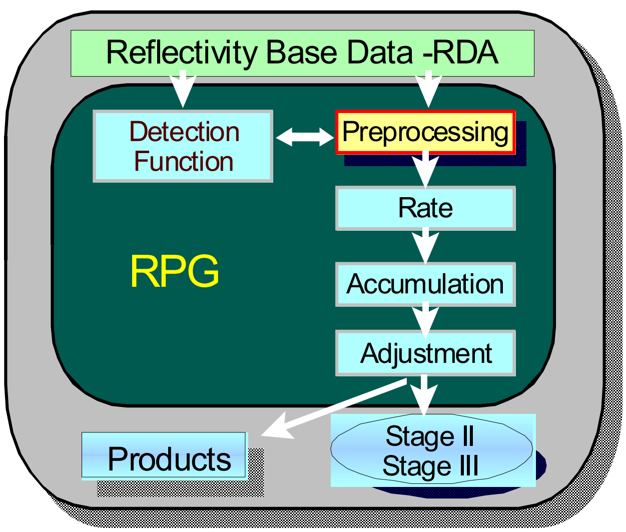


Figure 5-2. EPRE is a replacement for the legacy Preprocessing algorithm.

The EPRE algorithm provides the necessary changes to accept ***any*** new VCP for precipitation processing. The EPRE is not limited to the lowest four elevation angles. Thus the EPRE was necessary to implement VCPs 12 and 121 with RPG Build 5.

Begin and End of Rainfall Accumulations with EPRE

The EPRE includes a function that determines when rainfall accumulations begin and end. This function is performed on the Hybrid Scan (discussed later) after it is assembled. The areal coverage of returns greater than a minimum dBZ value is compared to areal coverage and dBZ thresholds (URC editable adaptable parameters). In Figure 5-3, note that the EPRE adaptable parameters are listed under Hydromet Preprocessing. These parameters are:

- Reflectivity (dBZ) Representing Significant Rain (RAINZ), and
- Area with Reflectivity Exceeding Significant Rain Threshold (RAINA).

The default value for RAINZ is 20.0 dBZ, which is considered to be the lowest dBZ for ***liquid*** precipitable returns.

The default value for RAINA is 80 km^2. For most locations, this areal coverage will likely be too low, resulting in accumulations in clear air. An appropriate setting representing typical residual clutter will need to determined locally.

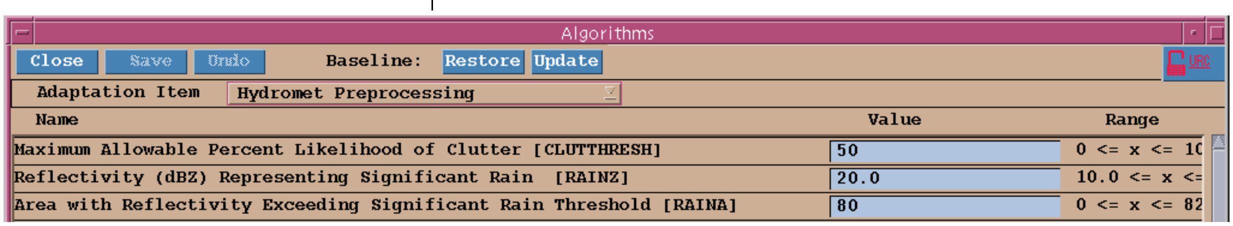


Figure 5-3. EPRE adaptable parameters window with URC editable parameters enabled. Note the reflectivity (RAINZ) and areal coverage (RAINA) thresholds.

There is a one hour waiting period to reset the accumulations to zero. This is controlled by the adaptable parameter Threshold Time without Rain for Resetting STP (RAINT). The default value is 60 minutes at the ROC level, thus RAINT is currently not editable.

If the EPRE determines that it is raining, accumulations will occur regardless of the weather mode or VCP. The RAINA threshold will need to be set to reflect the typical coverage of residual clutter for each site.

It will still be necessary to address AP events with the appropriate clutter filtering. Unsuppressed AP will likely exceed the areal coverage threshold and initiate rainfall accumulations.

How to Determine Typical Residual Clutter

Supplemental Precipitation Data (SPD) Product

The Supplemental Precipitation Data (SPD) product is a text product available at the AWIPS workstation using the command WSRSPDXXX. The SPD can be put on an RPS list, or it can be requested. The SPD is generated each volume scan and contains information from the Precipitation Processing algorithms. The SPD is on the national RPS list for NWS sites, but will need to be requested from DoD radars(see Fig. 5-4 on page 154).

The “TOTAL RAIN AREA” provides the areal coverage of returns that exceed the dBZ threshold (RAINZ). Checking this value on several days where no precipitation or AP is present should provide an estimate of the typical areal coverage of residual clutter.

Exclusion Zones

Some WSR-88D sites have areas where appropriate clutter filtering cannot sufficiently remove non-meteorological returns and significant residual

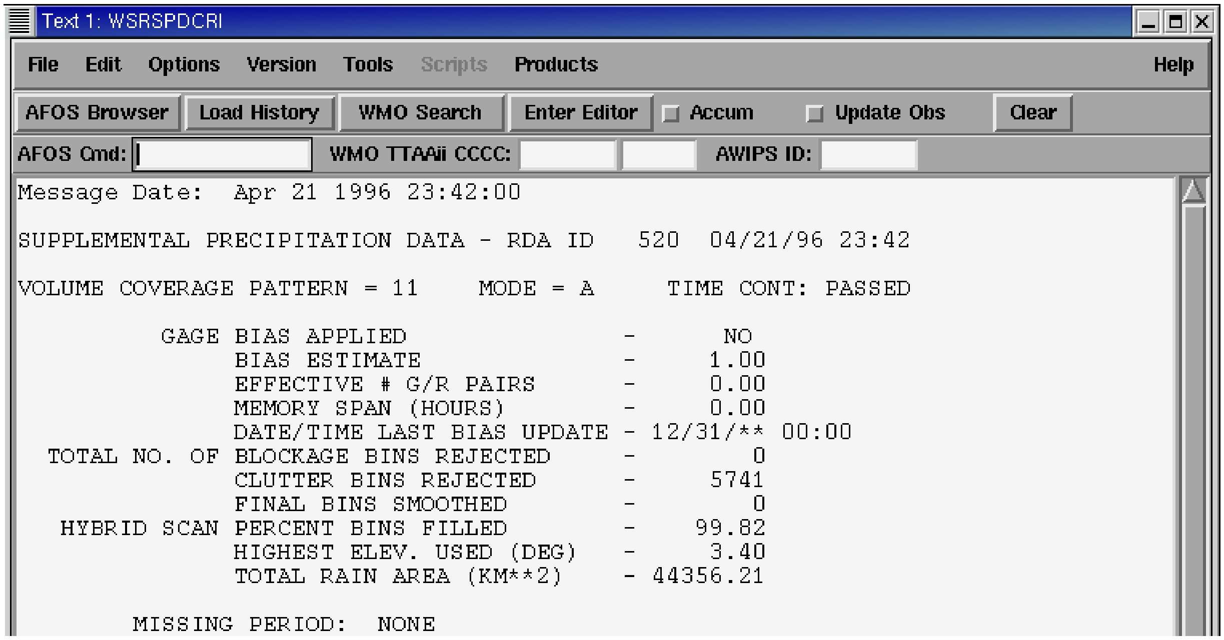


Figure 5-4. Supplemental Precipitation Data (SPD) product.

clutter remains. This type of residue is usually the result of:

- very high power from ground targets that cannot be entirely removed by the filters, such as mountain ranges
- moving ground targets like cars on an overpass, or
- stationary targets that are in motion, such as wind generators or wind blown trees.

The EPRE allows sites to define exclusion zones that remove the reflectivity data within these zones from precipitation processing. The definition of exclusion zones is typically the duty of the radar focal point. Additional information on defining exclusion zones can be found in the RPG Build 5 and RPG Build 6 Training (http://www.wdtb.noaa.gov).

Radar Echo Classifier (REC)

The EPRE uses the Radar Echo Classifier (REC) algorithm to identify AP/Clutter. The REC processes all three moments of the base data. For a particular range bin, the REC assigns a likelihood, as a percentage, that the returns are from clutter. The REC generates two products that display the likelihood percentages, Clutter Likelihood Reflectivity (CLR) and Clutter Likelihood Doppler (CLD).

The EPRE uses these percentages to reject data suspected as clutter. An adaptable parameter, the Maximum Allowable Percent Likelihood of Clutter (CLUTTHRESH), identifies which bins will be rejected from precipitation processing because the returns are likely to be from clutter.

The default value for CLUTTHRESH is 50% (Figure 5-5). Thus if the % ≤ 50, a range bin reflectivity value is retained and if the % > 50, the range bin reflectivity is rejected. If the range bin reflectivity value is not used, the reflectivity value for the next higher elevation will be tested for use for that bin.

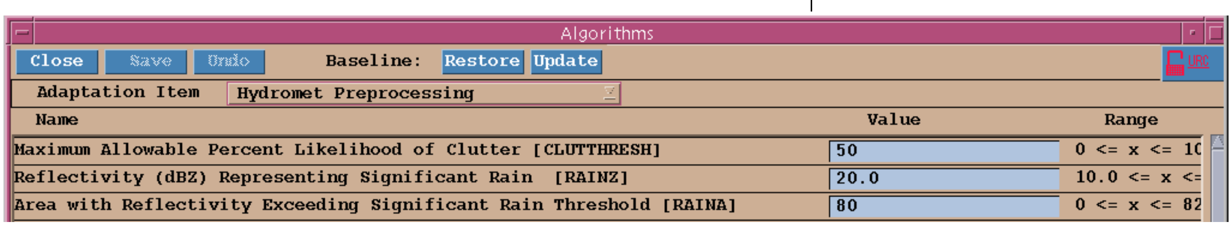


Figure 5-5. Clutter threshold entry in the Hydromet Preprocessing parameters window.

Though likely to be a rare event, it may be desirable to increase the CLUTTHRESH value if there is a suspicion that real precipitation is being removed as clutter. This problem may occur in areas of mixed AP and precipitation.

REC Performance in Range Folded Areas

Since the REC AP/Clutter identification process uses all three base moments, it will perform best in regions where valid velocity data are available. In areas of range folding, the REC results are based only on the reflectivity data, and are less reliable. Reflectivity values from radar bins with valid precipitation in areas of range folding may be replaced by values from higher elevations, potentially degrading rainfall estimates in flash flooding. In a case where extensive range folding corresponds with valid precipitation, increasing CLUTTHRESH may be desirable.

The EPRE's reliance on the REC to identify AP/Clutter will allow for the use of significantly more reflectivity data from lower tilts compared to the Tilt Test.

REC Performance in Case Studies

The REC has performed well in case studies where there is AP mixed with precipitation. However, in cases where there is widespread AP, the REC has not always identified it. The residual AP has been apparent on the precipitation products.

To mitigate the problem of residual clutter (normal or AP) close to the RDA, some of the lower elevation angles are not used at close ranges. This solution is similar to the legacy hybrid scan, where fixed elevations were used at fixed ranges. The result is an occasional ring structure on the products.

See See Fig. 5-7 on page 158, for product examples of both residual AP and rings near the RDA.

EPRE Hybrid Scan

With the EPRE algorithm, the hybrid scan construction is no longer limited to the lowest four elevation angles. Starting with the 0.5° elevation, the reflectivity value for each range bin is accepted based on the following criteria:

1. Beam blockage no more than 50%,

2. Does not fall within an exclusion zone, and
3. The REC clutter likelihood is no more than 50% (CLUTTHRESH).

If any of these conditions are ***not*** met, the reflectivity value from the next higher elevation is checked.

The construction of the hybrid scan continues until it is at least 99.7% full. On the SPD product (see Fig. 5-4 on page 154), the Hybrid Scan Percent Bins Filled is listed for each volume scan. For most sites, this process is completed within the lower 2 or 3 elevations. For more mountainous sites, the lower 4, 5 or even 6 elevations (especially with VCP 12) will be needed to build the hybrid scan. Thus the timing of precipitation products within the volume scan will vary somewhat from site to site.

Note that the EPRE will allow for more use of low level reflectivity values for precipitation processing than the legacy algorithm.

Due to the EPRE's techniques for removing residual clutter and AP, there are features of the precipitation products that may occur more frequently than with the legacy algorithm.

AP and Residual Clutter from Terrain

Results from case studies with the EPRE have shown that in widespread AP events, particularly where the AP has not been appropriately filtered at the RDA, the AP will show up on the precipitation products. See Figure 5-6 and Figure 5-7 for an example of ***unfiltered AP*** that is not successfully identified by the REC algorithm, and thus not removed by the EPRE. In Figure 5-6, a line of showers is southeast of the RDA, with a large area of AP north and west.

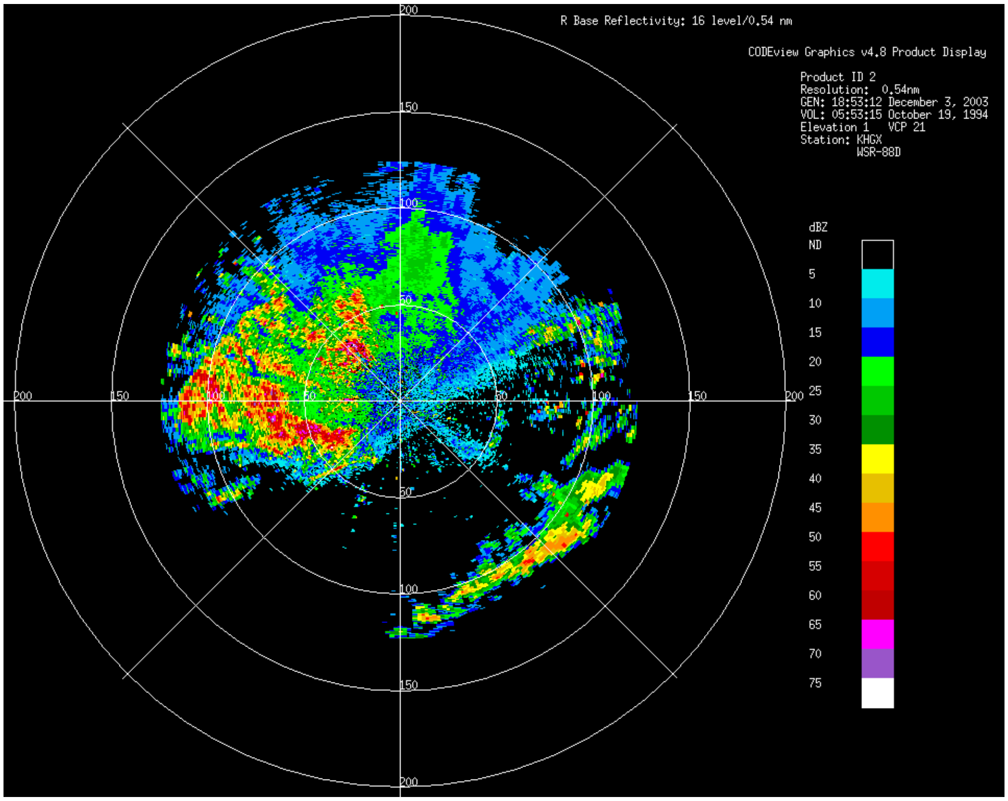


Figure 5-6. Significant AP to the north and west with a line of showers to the southeast

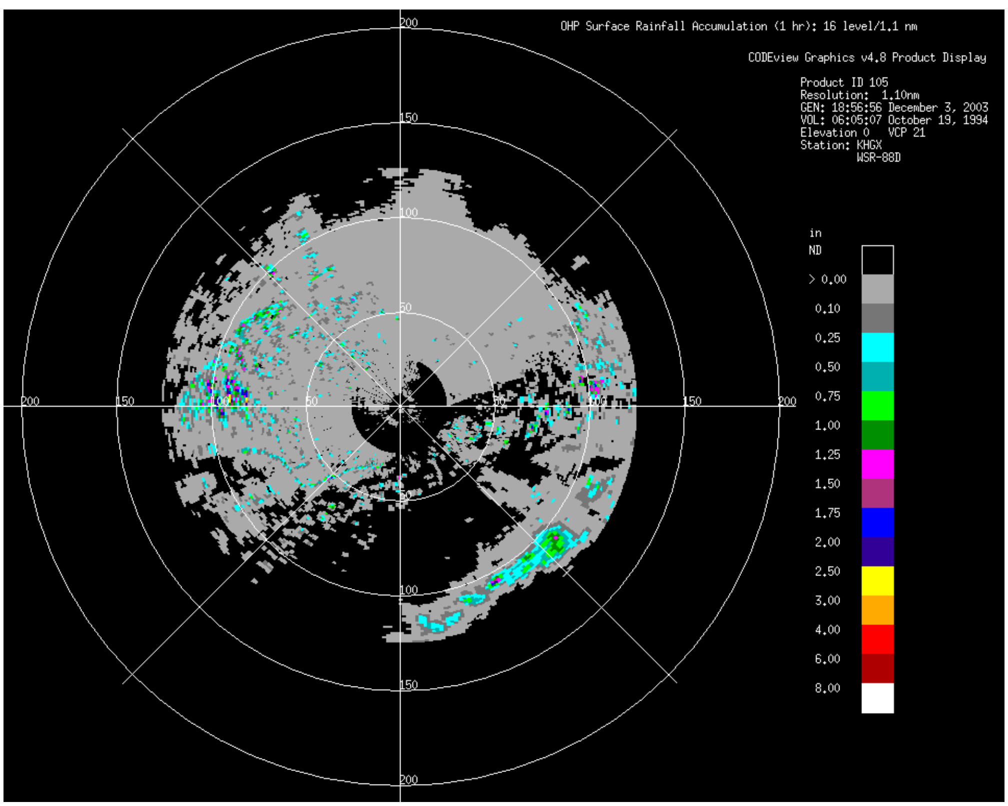


Figure 5-7. Significant AP to the north and west is not rejected and is converted to rainfall accumulations.

In Figure 5-7, the One Hour Precipitation (OHP) product shows that most of the AP was not successfully identified by the REC and thus not removed by the EPRE. Also note the ring structure close to the RDA. This is a result of the exclusion of lower elevations at close ranges.

For sites that have mountainous terrain, residual clutter is a typical problem. Careful adjustment of the RAINA parameter and creation of exclusion zones may be needed to avoid contamination of precipitation products. As with AP, residual clutter may not be successfully identified by the REC and thus not removed by the EPRE. In residual clutter is in numerous locations associated with mountain ranges. In Figure 5-9, some of this clutter has been accumulated in the Storm Total Precipitation (STP) product.

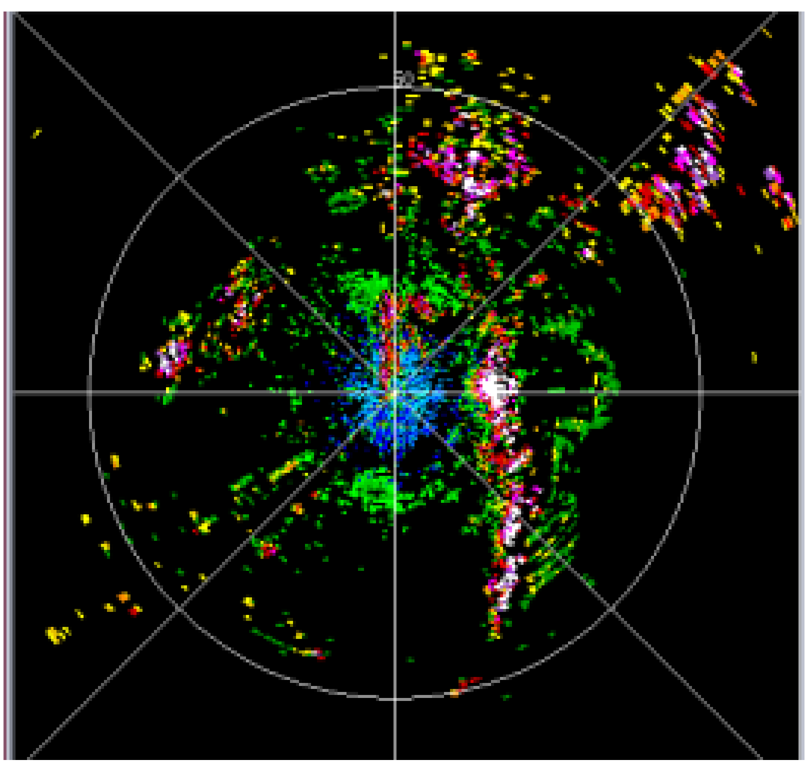


Figure 5-8. Residual clutter on Base Reflectivity resulting from mountainous terrain.

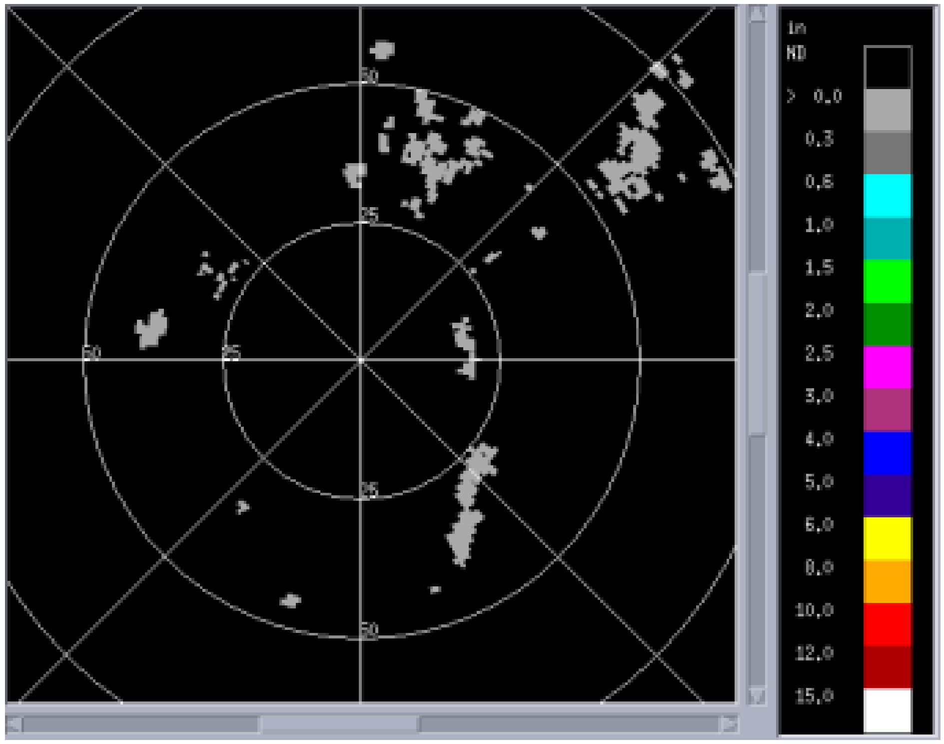


Figure 5-9. Residual clutter from mountainous terrain on a Storm Total Precipitation product.

Ring Structure Near the RDA

To mitigate residual clutter and potentially high accumulations close to the RDA, some of the lower elevations are excluded at close ranges. Specifically:

- From 0 to 5 nm, all elevations at or below 1.6° are excluded.
- From 5 to 9 nm, all elevations at or below 1° are excluded.
- From 9 to 25 nm, all elevations at or below 0.6° are excluded.

The result is an occasional ring structure close to the RDA on the precipitation products. In Figure 5-10, this structure is apparent on an STP product. Near the range of 25 nm, the returns are from 1.5° since 0.5° is excluded. Just beyond 25 nm, the rainfall is based on returns from 0.5°. This ring structure will be most apparent in low topped stratiform events and least likely with deep convection.

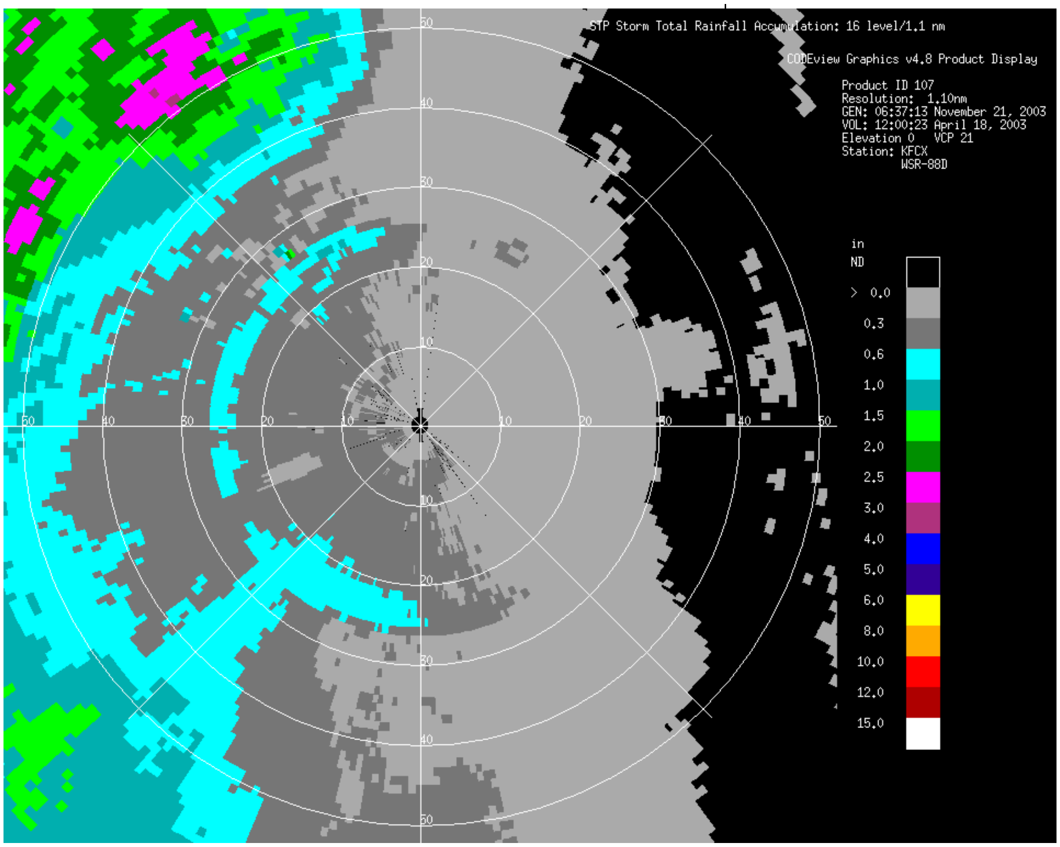


Figure 5-10. Ring structure close to the RDA on a Storm Total Precipitation product.

Interim Summary

Digitized Base Reflectivity Data are transmitted to the RPG for processing.

Precipitation Detection Function

The Precipitation Detection Function (PDF) determines if precipitation is occurring within 124 nm of the radar and assigns a precipitation category each volume scan (Category 0 - No precipitation Category 1 - Precipitation, Category 2 - Light precipitation). If in Clear Air Mode (VCP 31 or 32), assignment of Category 1 automatically switches radar to VCP 21.

Enhanced Precipitation Preprocessing (EPRE)

EPRE determines when the accumulation of precipitation begins and ends in the Precipitation Preprocessing subsystem. It attempts to reduce the impacts of clutter and AP, and results in the construction of the Hybrid Scan.

Hybrid Scan Reflectivity (HSR)

HSR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: 4 bit Hyb Scan Refl
- UNITS: (dBZ)
- DATE: Day of week, time, and date **in UTC**

HSR product annotations:

- VCP: 11, 12, 21, 121, 31 or 32

Additional HSR product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 0.54nm X 1 degree
- DATA LEVELS: 16 data levels from +5 dBZ to + 75 dBZ.

Available every volume scan

A 16 data level reflectivity product from the four lowest elevation angles of base reflectivity.

Note: Do not confuse the HSR product with the Digital Hybrid Scan Reflectivity (DHR).

Hybrid Scan Reflectivity Applications

1. View reflectivity used for precipitation products.
2. Assess the accuracy of the precipitation products.
3. Quickly search for inconsistencies in the data.
4. Assist operator in discriminating between precipitation returns and ground returns due to anomalous propagation.

Hybrid Scan Reflectivity Limitations

1. Ground clutter and AP is sometimes displayed on the Hybrid Scan Reflectivity.

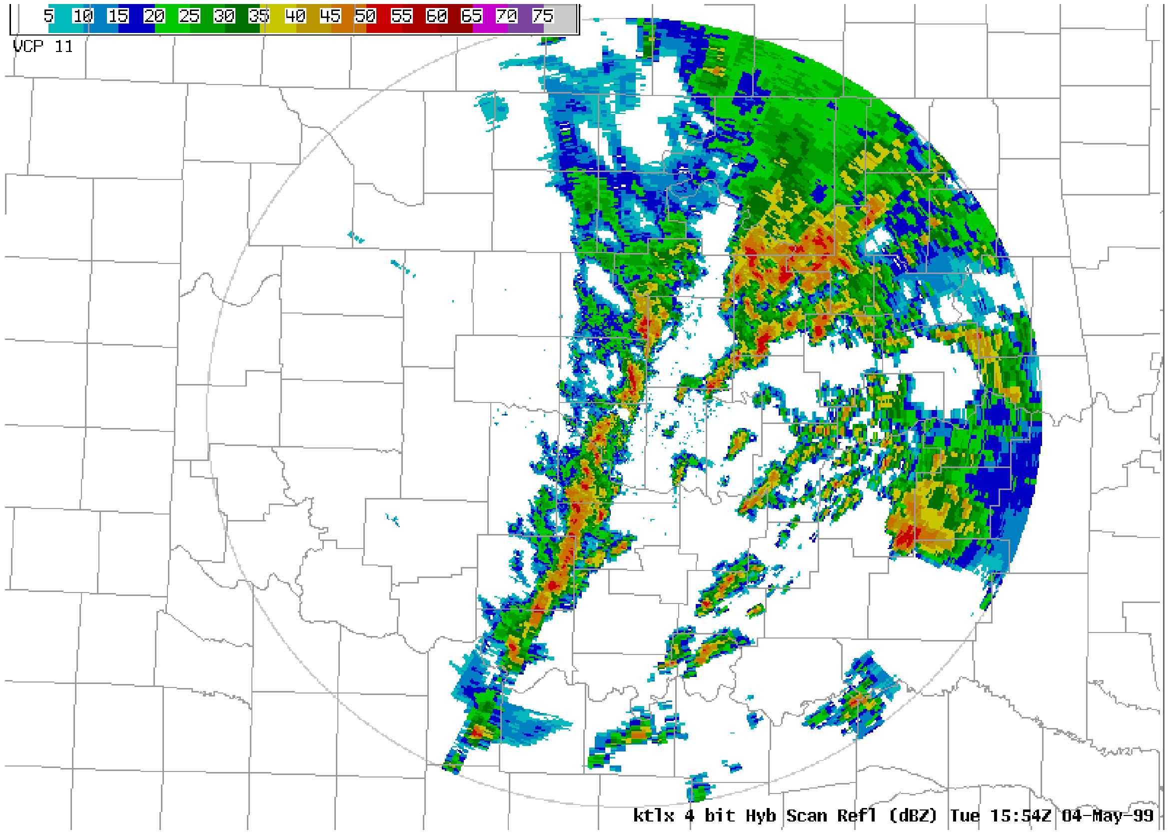


Figure 5-11. Hybrid Scan Reflectivity

Digital Hybrid Scan Reflectivity (DHR)

DHR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Hybrid Scan Refl
- UNITS: (dBZ)
- DATE: Day of week, time, and date **in UTC**

DHR product annotations:

- VCP: 11, 12, 21, 121, 31 or 32

Additional DHR product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- DATA LEVELS: 256 data levels from -28 dBZ to + 90 dBZ. (0.5 dBZ increments)

Available every volume scan.

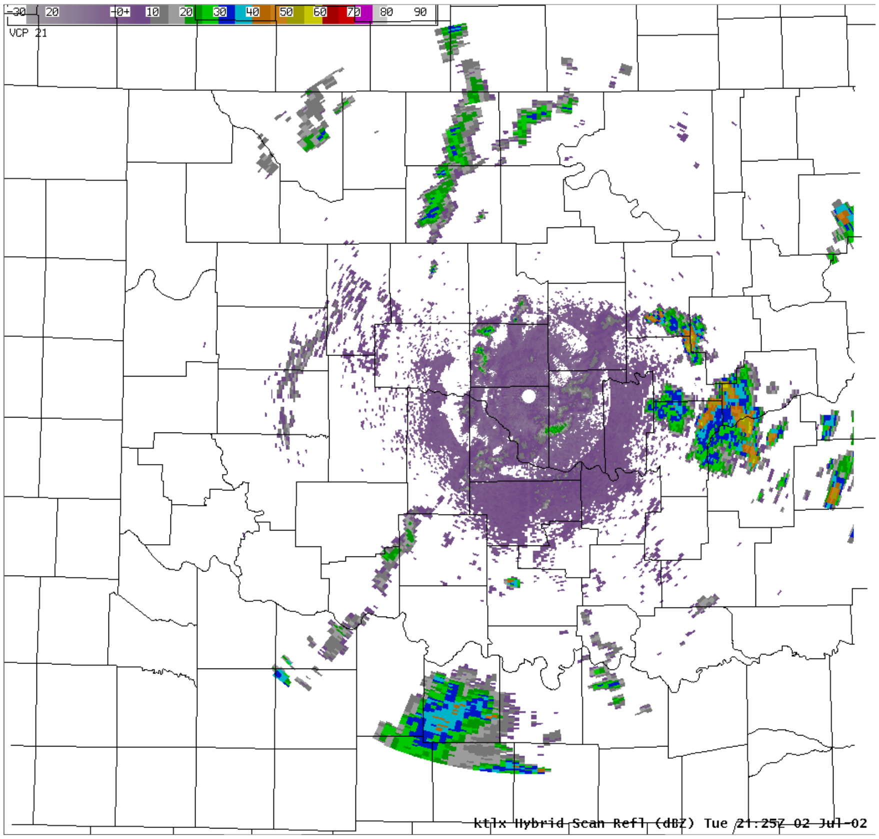


Figure 5-12. Digital Hybrid Scan Reflectivity (DHR)

Displays reflectivity data used to produce the precipitation products.

DHR Applications

1. High resolution (256 data levels) allows for innovative color tables.
2. High accuracy (0.5 dBZ).
3. Used in the generation of external products.
    - Flash Flood Monitoring and Prediction (FFMP)
    - Jendrowski Scripts (Multiple Z/R AWIPS App)
    - Areal Mean Basin Estimated Rainfall (AMBER)

DHR Limitation

1. Large product size

Precipitation Rate Algorithm

The input to the Precipitation Rate algorithm is the best possible low level reflectivity value at each 0.54 nm x 1° range bin that was created by the Preprocessing Algorithm (Hybrid Scan). The reflectivity data (dBZ) are converted to rainfall rates (dBR, decibels of R, dBR=10 log R) using a Z-R relationship. The Rate Algorithm then performs a resolution change.

Converts 0.54 nm x 1° rate data to 1.1 nm x 1°

The rainfall rates at the 0.54 nm x 1°resolution are converted to a new resolution, 1.1 nm x 1°. This is done by averaging the rates in two adjacent 0.54 nm range bins, and placing the average in the corresponding 1.1 nm bin.

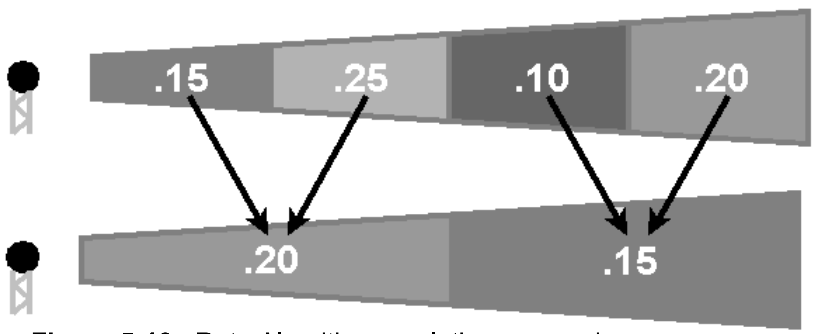


Figure 5-13. Rate Algorithm resolution conversion process

Maximum Precipitation Rate Allowed

The parameter *Maximum Precipitation Rate Allowed* should correspond to the Z/R relationship used. The default setting is 103.8 mm/hr, which equates to 4.09 in/hr (see Fig. 5-14). This value corresponds to the default Z/R relationship ($300R^{1.4}$). If the Z/R relationship is changed, a corresponding change to the *Max Precipitation Rate* should also be made.

Maximum Precipitation Rate Allowed Implications

Currently, one tropical and three stratiform specific Z/R relationships can be invoked at the RPG HCI. With any of these Z/R relationships invoked and *Maximum Precipitation Rate Allowed* left at its default setting, rainfall rates would still be capped at 4.09 in/hr. This could cause significant underestimation using the tropical Z/R relationship (250R$^{1.2}$). When using the tropical Z/R, the *Max Precipitation Rate* should be changed to 154.2 mm/hr, which equates to 6.00 in/hr. For more information on the various Z/R relationships review the Precipitation Estimation section of IC 5.3.

Precipitation Accumulation Algorithm

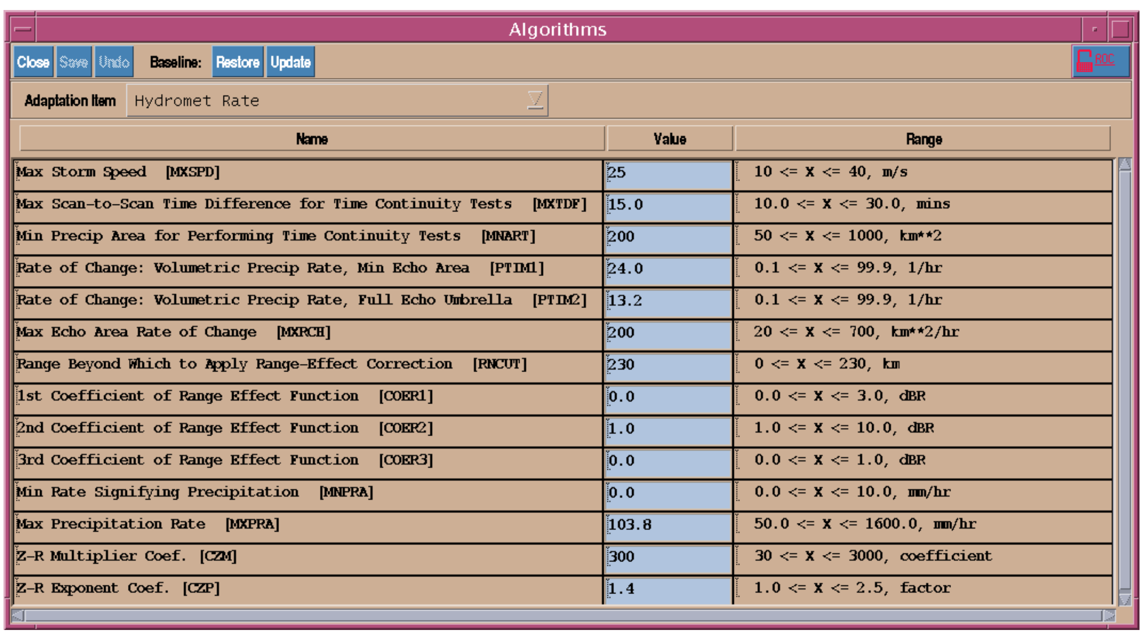
The Precipitation Accumulation algorithm takes the output from the Precipitation Rate algorithm (rainfall rates for each 1° X 1.1 nm bin) and produces scan to scan and hourly accumulations for each 1° X 1.1 nm range bin. The Precipitation Accumulation algorithm also checks for missing rate scans.

Scan-to-Scan Accumulations

The volume scan to volume scan accumulations are produced for the Storm Total Precipitation Product. The Storm Total will update each volume scan for the duration of category 1 or 2.

Hourly Accumulations

There are two types of hourly accumulations that generate products:



Name	Value	Range
Max Storm Speed [MXSPD]	25	10 <= X <= 40, m/s
Max Scan-to-Scan Time Difference for Time Continuity Tests [MXTDF]	15.0	10.0 <= X <= 30.0, mins
Min Precip Area for Performing Time Continuity Tests [MNART]	200	50 <= X <= 1000, km**2
Rate of Change: Volumetric Precip Rate, Min Echo Area [PTIM1]	24.0	0.1 <= X <= 99.9, 1/hr
Rate of Change: Volumetric Precip Rate, Full Echo Umbrella [PTIM2]	13.2	0.1 <= X <= 99.9, 1/hr
Max Echo Area Rate of Change [MXRCH]	200	20 <= X <= 700, km**2/hr
Range Beyond Which to Apply Range-Effect Correction [RNCUT]	230	0 <= X <= 230, km
1st Coefficient of Range Effect Function [COER1]	0.0	0.0 <= X <= 3.0, dBR
2nd Coefficient of Range Effect Function [COER2]	1.0	1.0 <= X <= 10.0, dBR
3rd Coefficient of Range Effect Function [COER3]	0.0	0.0 <= X <= 1.0, dBR
Min Rate Signifying Precipitation [MNPRA]	0.0	0.0 <= X <= 10.0, mm/hr
Max Precipitation Rate [MXPRA]	103.8	50.0 <= X <= 1600.0, mm/hr
Z-R Multiplier Coef. [CZM]	300	30 <= X <= 3000, coefficient
Z-R Exponent Coef. [CZP]	1.4	1.0 <= X <= 2.5, factor

Figure 5-14. Hydromet Rate Algorithm adaptable parameters edit screen at RPG HCI.

The first type of hourly accumulation is one hour ending at the current volume scan, and is used to produce the One Hour Product. The One Hour Product is a **moving** one hour window that is updated:

1. One hour ending at the current volume scan

- every 4 to 6 minutes in mode A (depending on VCP)
- every 10 minutes if in mode B

The second type of hourly accumulation is one hour ending at the top of the hour. Two out of three top of the hour (or clock hour) accumulations are required to produce a Three Hour Product. This product is available each volume scan, but the accumulations are updated ***only*** at the top of each hour.

2. One hour ending at the top of each hour

Rain starts at 2:43 PM and stops at 4:30 PM.

Example

The first nonzero accumulation would be one hour ending at 3:00 PM. The second nonzero accumulation would be one hour ending at 4:00 PM, and the third would be one hour ending at 5:00 PM.

The Three Hour Product would be available the first volume scan after 3:00 PM, since two top of the hour accumulations would be available:

- 1:00 - 2:00, zero accumulation
- 2:00 - 3:00, nonzero accumulation

The User Selectable Precipitation (USP) Product is also created using top of the hour accumulations. Two thirds of the requested time period must be available for product generation. Like the Three Hour Product, the USP is available each volume scan, but will only contain accumulations ending at the top of the clock hour.

Check for Missing Data

The Accumulation algorithm also checks for and attempts to correct for missing rate scans. As the time between scans increases, so also increases the error in the precipitation estimate. For example, an outage time of 10 minutes statistically results in 15% error, while an outage time of 15 minutes results in 25% error. In this setting, an outage is any type of failure that prevents base data from being received at the RPG.

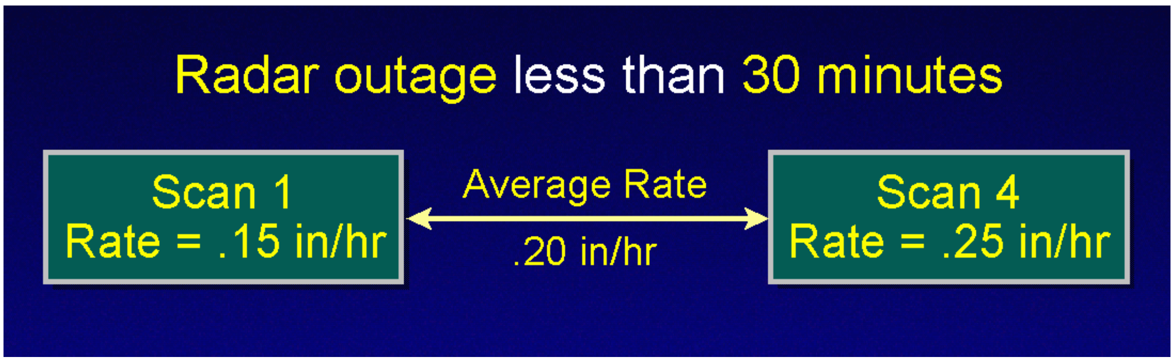


Figure 5-15. Radar outage less than 30 minutes. No data are labeled missing.

In the Accumulation algorithm, if the time between consecutive scans is less than or equal to 30 minutes, the precipitation rates are averaged between the last good volume scan and the first good one. This average is then multiplied by the time between scans (outage time), to compute an accumulation. See Fig. 5-15.

If the time between consecutive volume scans is greater than 30 minutes, the Accumulation algorithm extrapolates the rate from the last good volume scan for an additional 15 minutes. The final 15 minutes of the outage is assigned the rate from the first good volume scan after the outage. The excess time between these two extrapolations is labeled missing. See Fig. 5-16.

Figure 5-16. Radar outage longer than 30 minutes. Data beyond 30 minutes are labeled missing.

If missing data exceeds 6 minutes (radar outage exceeds 36 minutes), hourly accumulations are not computed.

1. One Hour Product not generated.
2. Three Hour Product not generated until 2 top of the hour accumulations (zero or nonzero) are available. This product may include missing data.
3. The User Selectable Precipitation Product is not generated unless 2/3 of the requested hourly accumulations are computed. When generated, the product may then contain periods of missing data. Missing data periods are listed on the USP attribute table.
4. Storm Total Product will be generated though data are missing.

In category 0, “zeros” are accumulated; a zero accumulation is ***not*** missing data.

Interim Summary

Hybrid Scan Reflectivity (HSR) Product

Hybrid Scan Reflectivity (HSR) is a **16** data level product depicting the reflectivity used for the precipitation products. The reflectivity depicted is output from the Preprocessing Algorithm, and has already undergone the quality control steps (tilt test, spurious noise, reflectivity outliers and terrain blockage).

Digital Hybrid Scan Reflectivity (DHR) Product

Digital Hybrid Scan Reflectivity (DHR) is a **256** data level product of the reflectivity used for the precipitation products.The reflectivity depicted is output from the Preprocessing Algorithm, and has already undergone the quality control steps (tilt test, spurious noise, reflectivity outliers and terrain blockage).

Rate Algorithm

The Rate Algorithm converts Reflectivity to Rainfall Rate and changes resolution from 0.54 nm x 1° to 1.1 nm x 1°

Accumulation Algorithm

The Accumulation Algorithm computes scan-to-scan and hourly accumulations and checks for missing periods of data.

Precipitation Adjustment Algorithm

The precipitation adjustment algorithm attempts to correct for two errors that have proven difficult:

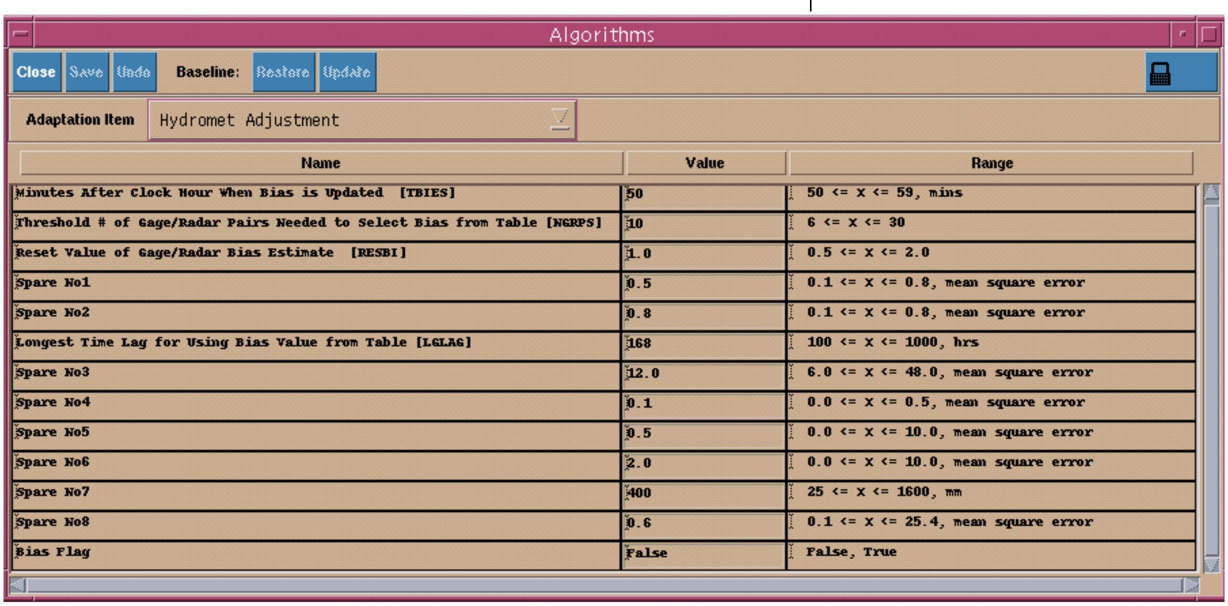
1. Non-representative Z-R relationship
2. Incorrect hardware calibration

AWIPS generates Bias Tables using the AWIPS Multisensor Precipitation Estimator (MPE) function. These tables are transmitted on a regular hourly basis (or more frequently at operator discretion) to the RPG associated with that WFO. The Bias Table reflects gage/radar differences over various time scales, and is input to the Precipitation Adjustment Algorithm at the RPG.

A Bias Flag (True/False) is set at the RPG to determine whether the multiplicative bias will be used or not. If the Bias Flag is set to True a multiplicative Bias will be made to the both the scan-to-scan and hourly accumulation over the entire 124 nm range.

Bias Effect on Products

When the Bias Flag is set to true, the bias is applied differently on the precipitation products.


Algorithms

Close Save Undo Baseline: Restore Update

Adaptation Item: Hydromet Adjustment

Name	Value	Range
Minutes After Clock Hour When Bias is Updated [TBIES]	50	50 <= X <= 59, mins
Threshold # of Gage/Radar Pairs Needed to Select Bias from Table [NGRPS]	10	6 <= X <= 30
Reset Value of Gage/Radar Bias Estimate [RESBI]	1.0	0.5 <= X <= 2.0
Spare No1	0.5	0.1 <= X <= 0.8, mean square error
Spare No2	0.8	0.1 <= X <= 0.8, mean square error
Longest Time Lag for Using Bias Value from Table [LGLAG]	168	100 <= X <= 1000, hrs
Spare No3	12.0	6.0 <= X <= 48.0, mean square error
Spare No4	0.1	0.0 <= X <= 0.5, mean square error
Spare No5	0.5	0.0 <= X <= 10.0, mean square error
Spare No6	2.0	0.0 <= X <= 10.0, mean square error
Spare No7	400	25 <= X <= 1600, mm
Spare No8	0.6	0.1 <= X <= 25.4, mean square error
Bias Flag	False	False, True

Figure 5-17. Hydromet Adjustment Algorithm adaptable parameters edit screen at RPG HCI.

- One Hour Precipitation (OHP) - Bias applied to entire hour of accumulation.

- Three Hour Precipitation (THP) and User Selectable Precipitation (USP) - Each top-of-the-hour's bias used.

- Storm Total Precipitation (STP) - Each volume scan bias used

A Word of Caution

The Bias Flag default is False. Caution should be used when setting the Bias Flag to True. The bias is available to correct for non-representative Z-R relationships or incorrect hardware calibrations. Bias values may be produced by other factors such as rain gage inaccuracies and below beam effects (strong winds, evaporation, or coalescence). Also the sampling area of a rain gage is considerably smaller than the radar range bin, especially at long ranges.

Precipitation Processing Subsystem - Strengths

Only source of real time high resolution rainfall accumulations.

Uses the best possible reflectivity (closes to the ground) to convert to rainfall

Significant quality controls are designed to produce better products by:

1. minimizing overestimation due to ground return caused by anomalous propagation, and
2. reducing the effects of beam blockage.

Precipitation Processing Subsystem - Limitations

Algorithms do not account for:

1. below beam effects (wind, evaporation, coalescence),
2. non-uniform Z/R relationships within the radar coverage area.

Algorithms do not always account for:

1. bright band contamination,
2. hail contamination, and
3. inaccuracies due to radar outages.

Summary - Algorithm Section

The Enhanced Preprocessing Algorithm performs quality control steps and constructs the hybrid scan.

The Rate Algorithm converts Reflectivity to rainfall rate.

The Accumulation Algorithm computes scan-to-scan and hourly accumulations.

The Adjustment Algorithm applies a multiplicative bias computed at AWIPS using rain gage to radar comparisons.

Precipitation Products

- One Hour Precipitation (OHP)
- Three Hour Precipitation (THP)
- Storm Total Precipitation (STP)
- User Selectable Precipitation (USP)
- One Hour Digital Precipitation Array (DPA)
- Supplemental Precipitation Data (SPD)

One Hour Precipitation

OHP product legend description: (Fig. 5-18)

- RPG ID: kxxx
- PRODUCT NAME: One Hour Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

OHP product annotations:

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.
- BIAS/ERR: The multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False.
- END: This is the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional OHP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 12.70 inches in multiples of 0.05 inch. Data level values are selected at the RPG HCI, and are under URC change authority.

Displays accumulations for the past hour.

Available from the first volume scan with detected rainfall (category 1 or 2).

Updated every volume scan after the first product - a moving one hour window of precipitation.

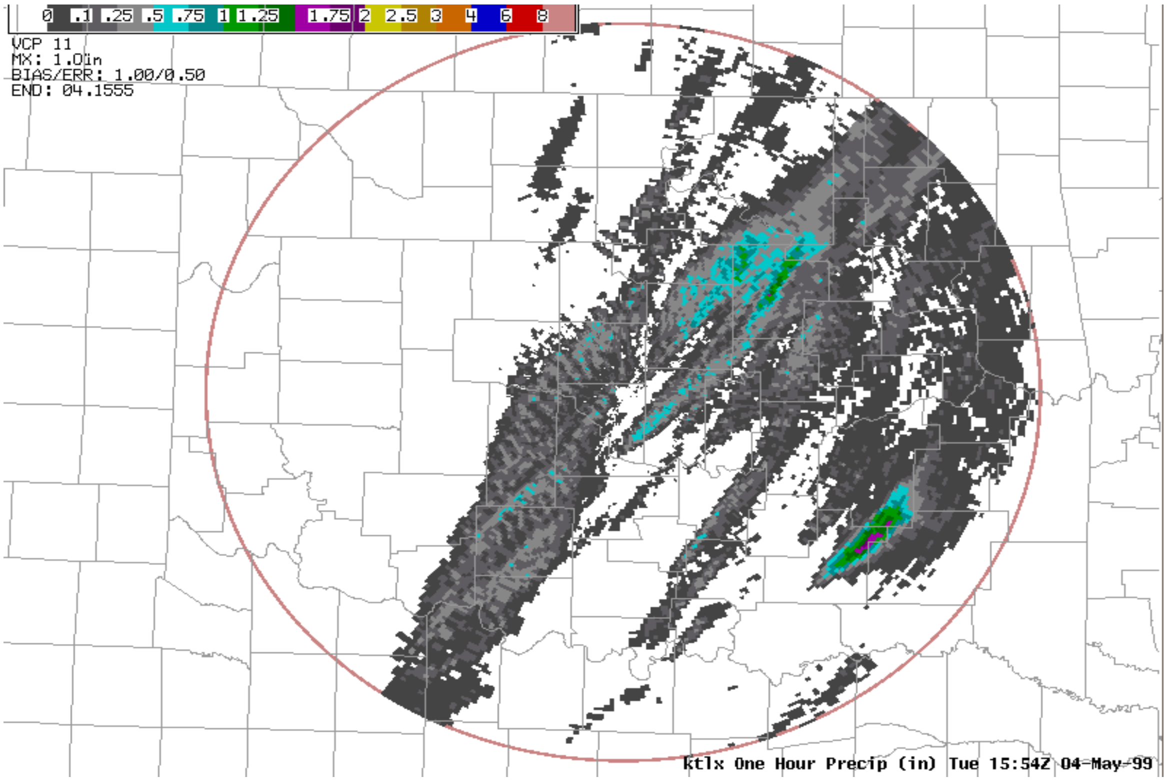


Figure 5-18. One Hour Precipitation

One Hour Precipitation - Applications

1. Assess rainfall accumulations for flash flood watches, warnings, and statements
2. Nowcasts and special weather statements
3. Time lapse can provide storm movement
4. Other water management applications

One Hour Precipitation - Limitations

1. After extended outages, first product will not be generated for 54 minutes
2. For some events, viewing interval too short

```
Text 1: WSROHPTLX
File  Edit  Options  Version  Tools  Scripts  Products                    Help
Browser  Load cmd:  Enter Editor  Accum  Update Obs  Clear
        1-HOUR PRECIPITATION ACCUMULATION                   07/22/99 14:16


          GAGE/RADAR BIAS ESTIMATE .........................      1.0000
          ERROR VARIANCE OF BIAS ESTIMATE ..................      0.5000
          PRODUCT ADJUSTED BY BIAS ESTIMATE? ...............      NO
MIN THRESHOLD DBZ FOR ISOLATED BIN TEST.....................      18.00 DBZ
MAX DBZ ALLOWED BEFORE BEING LABELED AS OUTLIER.............      70.00 DBZ
TILT-TEST LOW REFLECTIVITY (DBZ) VALUE......................       1.00 DBZ
INNER RANGE LIMIT FOR TILT TEST.............................      40.00 KM
OUTER RANGE LIMIT FOR TILT TEST.............................     150.00 KM
MAX RANGE OF BI-SCAN MAXIMIZATION...........................     230.00 KM
MIN PRECIP ECHO AREA NEEDED FOR TILT TEST IN LOW ELEV.......     600.00 KM**2
MIN AREA-WGTD-REFLECT. NEEDED FOR TILT TEST IN LOW ELEV.....      10.00 DBZ
MAX % AREA REDUCTION BETWEEN 2 LOWEST ELEVATIONS............      75.00  %
REFLECT-TO-PRECIP RATE CONVERSION MULTIPLICATIVE COEFFICIENT     300.00
REFLECT-TO-PRECIP RATE CONVERSION POWER COEFFICIENT.........       1.40
MIN DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....       0.00 DBZ
MAX DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....      70.00 DBZ
MIN RANGE OF BI-SCAN MAXIMIZATION...........................     180.00 KM
MAX STORM SPEED (M/SEC).....................................      25.00 M/Sec
MAX SCAN-TO-SCAN TIME DIFFERENCE FOR TIME CONTINUITY TESTS..      15.00 MINUTES
MIN PRECIP-AREA FOR PERFORMING TIME CONTINUITY TESTS........     200.00 KM**2
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, MIN ECHO AREA.......      24.00 1/Hr
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, FULL ECHO UMBRELLA..      13.20 1/Hr
MAX ECHO-AREA RATE OF CHANGE ...............................     200.00 KM**2/Hr
RANGE BEYOND WHICH TO APPLY RANGE-EFFECT CORRECTION.........     230.00 KM
1ST COEFFICIENT OF RANGE-EFFECT FUNCTION....................       0.00 DBR
2ND COEFFICIENT OF RANGE-EFFECT FUNCTION....................       1.00
3RD COEFFICIENT OF RANGE-EFFECT FUNCTION....................       0.00
MIN RATE SIGNIFYING PRECIPITATION...........................       0.00 MM/Hr
MAX PRECIPITATION RATE......................................     103.80 MM/Hr
REINITIALIZATION TIME LAPSE THRESHOLD (FOR ACCUM PROCESS)...      60.00 MINUTES
MAX TIME DIFFERENCE BETWEEN SCANS FOR INTERPOLATION.........      30.00 MINUTES
MIN TIME NEEDED TO ACCUMULATE HOURLY TOTALS.................      54.00 MINUTES
THRESHOLD FOR HOURLY OUTLIER ACCUMULATION...................     400.00 MM
HOURLY GAGE ACCUMULATION SCAN ENDING TIME...................       0.00 MINUTES
MAX ACCUMULATION PER SCAN-TO-SCAN PERIOD....................     400.00 MM
MAX ACCUMULATION PER HOURLY PERIOD..........................     800.00 MM
MINUTES AFTER CLOCK HOUR WHEN BIAS IS UPDATED...............      50.00 MINUTES
THRESHOLD # OF GAGE/RADAR PAIRS NEEDED TO CALCULATE BIAS....       6.00
RESET VALUE OF GAGE/RADAR BIAS ESTIMATE.....................       1.00
RESET VALUE OF ERROR VARIANCE OF BIAS ESTIMATE..............       0.50
MAXIMUM ALLOWED ERROR VARIANCE OF BIAS ESTIMATE.............       0.80
THRESHOLD TIME DIFFERENCE FOR ACCUMULATION GAGES............      15.00 MINUTES
TIME DURING WHICH BIAS IS DRIFTED BACK TO RESET VALUE.......      12.00 HOURS
SYSTEM NOISE................................................       0.05
VARIANCE ADJUSTMENT FACTOR..................................       0.50
# OF STANDARD DEVIATIONS FOR DISCARDING GAGE/RADAR PAIRS....       2.00
MAX GAGE ACCUMULATION ALLOWED...............................     400.00 MM
MIN HRLY GAGE OR RADAR ACCUM. NEEDED FOR BIAS CALCULATION...       0.60 MM
```

Figure 5-19. OHP Alphanumeric Product (AWIPS Version 5.2.1 will change in AWIPS version 5.2.2)

Three Hour Precipitation

THP product legend description: (Fig. 5-20)

- RPG ID: kxxx
- PRODUCT NAME: Three Hour Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

THP product annotations:

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.

- BIAS/ERR: Each hours multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False.
- END: This is the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional THP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 12.70 inches in multiples of 0.05 inch. Data level values are selected at the RPG HCI, and are under URC change authority.

Product accumulations updated once per hour, at the top of the hour

Requires two out of past three top of the hour accumulations (zero or nonzero) for product generation

Not recommended for RPS list

Three Hour Precipitation - Applications

1. Provides a longer viewing interval
2. For very long duration events, can be used with Storm Total Product for analysis
3. Corresponds to timing of three hour flash flood guidance values

Three Hour Precipitation - Limitations

1. Product updated only once per hour

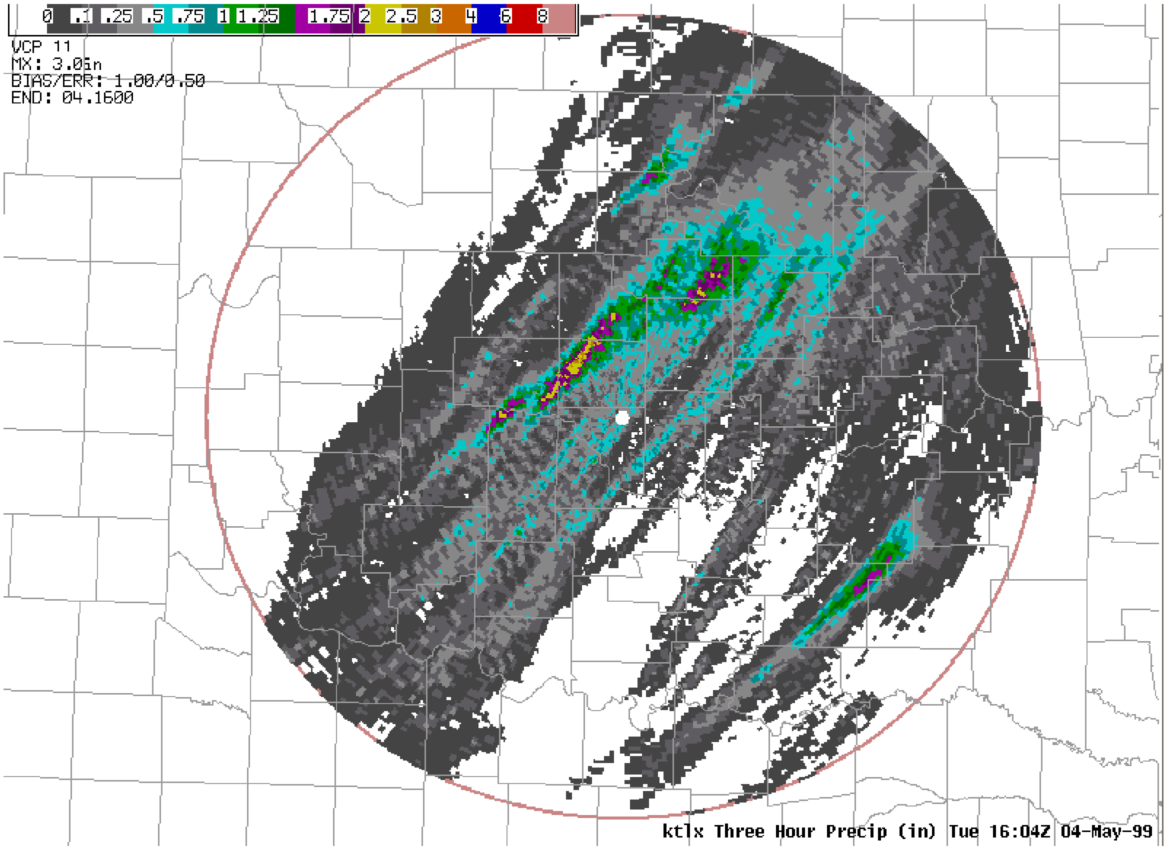


Figure 5-20. Three Hour Precipitation

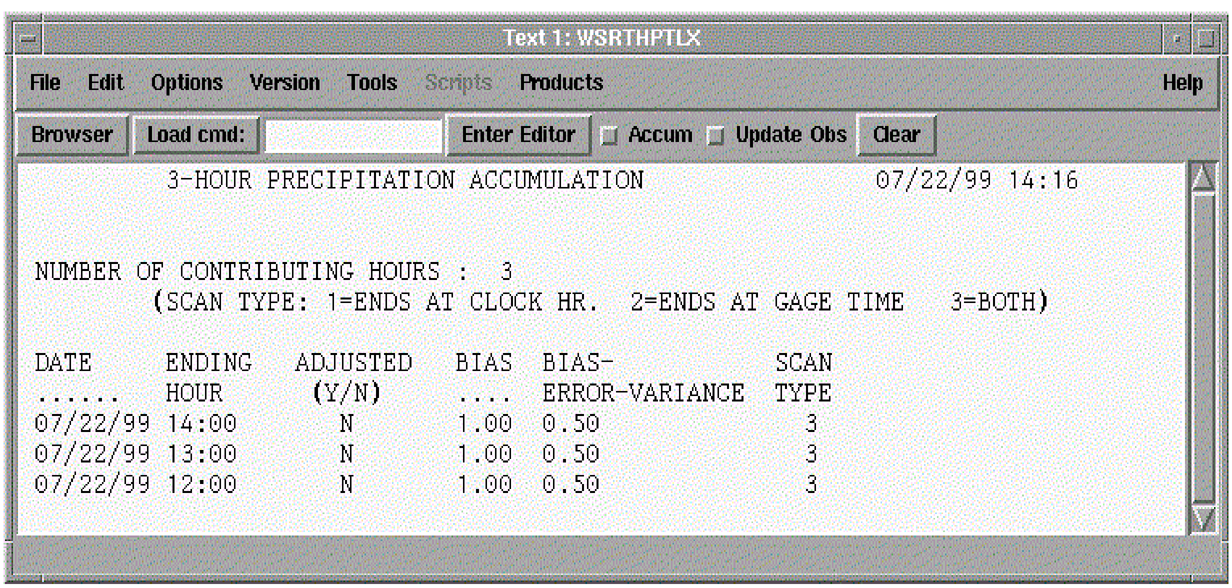


Figure 5-21. THP Alphanumeric Product (AWIPS Version 5.2.1 will change in AWIPS version 5.2.2)

Storm Total Precipitation

STP product legend description: (Fig. 5-22)

- RPG ID: kxxx
- PRODUCT NAME: Storm Total Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

STP product annotations:

- VCP: 11, 12, 21, 121, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.
- BIAS/ERR: The most recent multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False.
- BEG: Date/time of the first volume scan where category 1 or 2 was assigned.
- END: This the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional STP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 25.4 inches in multiples of 0.1 inch. Data level values selected at the RPG HCI (URC change authority).

Displays total rainfall accumulation.

Available from the first volume scan with detected rainfall (as determined by EPRE).

Updated every volume scan as long as precipitation meets EPRE thresholds.

Accumulations reset to zero after one hour of no precipitation.

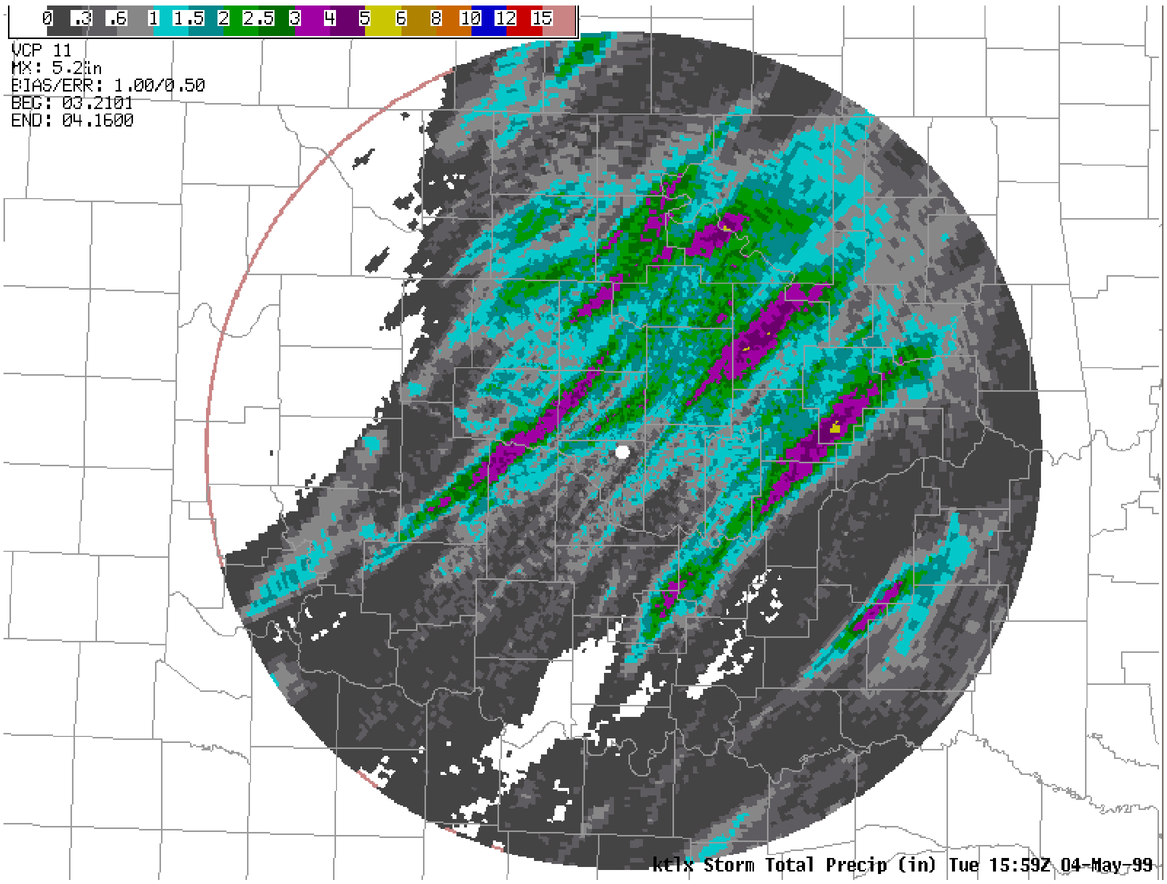


Figure 5-22. Storm Total Precipitation

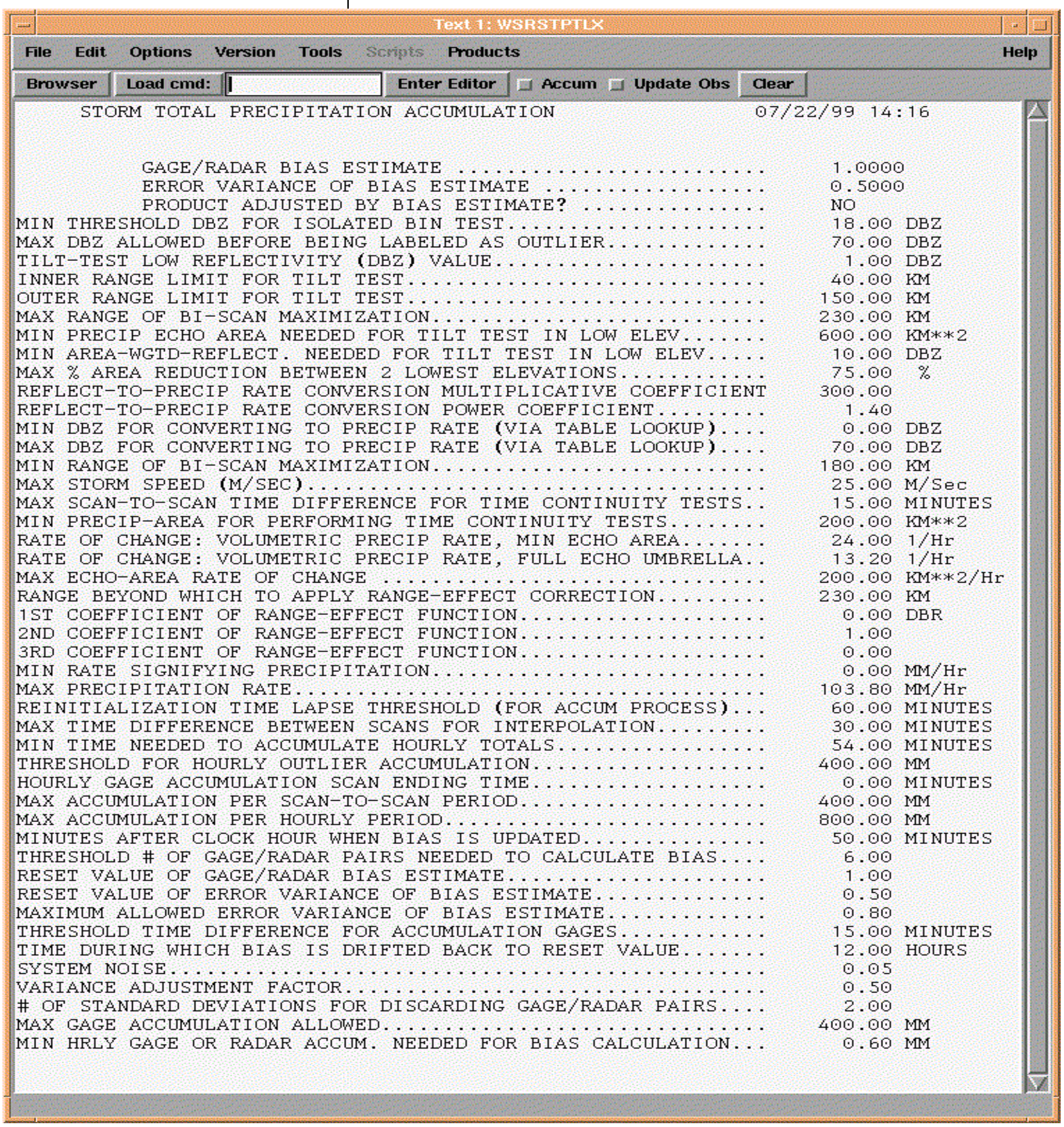
Storm Total Precipitation - Applications

1. Monitor total precipitation accumulation
2. Estimate ground saturation and/or total basin runoff
3. Post storm analysis
4. Time lapse for tracking motion of storms

Storm Total Precipitation - Limitations

1. Can display precipitation over extended periods of time - may need to be manually reset to zero (See RPG Build 6 Training for how to do this).

2. Could include missing data without the knowledge of the operator.




```
     STORM TOTAL PRECIPITATION ACCUMULATION                07/22/99 14:16


          GAGE/RADAR BIAS ESTIMATE .........................    1.0000
          ERROR VARIANCE OF BIAS ESTIMATE ..................    0.5000
          PRODUCT ADJUSTED BY BIAS ESTIMATE? ...............    NO
MIN THRESHOLD DBZ FOR ISOLATED BIN TEST.....................    18.00 DBZ
MAX DBZ ALLOWED BEFORE BEING LABELED AS OUTLIER.............    70.00 DBZ
TILT-TEST LOW REFLECTIVITY (DBZ) VALUE......................     1.00 DBZ
INNER RANGE LIMIT FOR TILT TEST.............................    40.00 KM
OUTER RANGE LIMIT FOR TILT TEST.............................   150.00 KM
MAX RANGE OF BI-SCAN MAXIMIZATION...........................   230.00 KM
MIN PRECIP ECHO AREA NEEDED FOR TILT TEST IN LOW ELEV.......   600.00 KM**2
MIN AREA-WGTD-REFLECT. NEEDED FOR TILT TEST IN LOW ELEV.....    10.00 DBZ
MAX % AREA REDUCTION BETWEEN 2 LOWEST ELEVATIONS............    75.00  %
REFLECT-TO-PRECIP RATE CONVERSION MULTIPLICATIVE COEFFICIENT   300.00
REFLECT-TO-PRECIP RATE CONVERSION POWER COEFFICIENT.........     1.40
MIN DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....     0.00 DBZ
MAX DBZ FOR CONVERTING TO PRECIP RATE (VIA TABLE LOOKUP)....    70.00 DBZ
MIN RANGE OF BI-SCAN MAXIMIZATION...........................   180.00 KM
MAX STORM SPEED (M/SEC).....................................    25.00 M/Sec
MAX SCAN-TO-SCAN TIME DIFFERENCE FOR TIME CONTINUITY TESTS..    15.00 MINUTES
MIN PRECIP-AREA FOR PERFORMING TIME CONTINUITY TESTS........   200.00 KM**2
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, MIN ECHO AREA.......    24.00 1/Hr
RATE OF CHANGE: VOLUMETRIC PRECIP RATE, FULL ECHO UMBRELLA..    13.20 1/Hr
MAX ECHO-AREA RATE OF CHANGE ...............................   200.00 KM**2/Hr
RANGE BEYOND WHICH TO APPLY RANGE-EFFECT CORRECTION.........   230.00 KM
1ST COEFFICIENT OF RANGE-EFFECT FUNCTION....................     0.00 DBR
2ND COEFFICIENT OF RANGE-EFFECT FUNCTION....................     1.00
3RD COEFFICIENT OF RANGE-EFFECT FUNCTION....................     0.00
MIN RATE SIGNIFYING PRECIPITATION...........................     0.00 MM/Hr
MAX PRECIPITATION RATE......................................   103.80 MM/Hr
REINITIALIZATION TIME LAPSE THRESHOLD (FOR ACCUM PROCESS)...    60.00 MINUTES
MAX TIME DIFFERENCE BETWEEN SCANS FOR INTERPOLATION.........    30.00 MINUTES
MIN TIME NEEDED TO ACCUMULATE HOURLY TOTALS.................    54.00 MINUTES
THRESHOLD FOR HOURLY OUTLIER ACCUMULATION...................   400.00 MM
HOURLY GAGE ACCUMULATION SCAN ENDING TIME...................     0.00 MINUTES
MAX ACCUMULATION PER SCAN-TO-SCAN PERIOD....................   400.00 MM
MAX ACCUMULATION PER HOURLY PERIOD..........................   800.00 MM
MINUTES AFTER CLOCK HOUR WHEN BIAS IS UPDATED...............    50.00 MINUTES
THRESHOLD # OF GAGE/RADAR PAIRS NEEDED TO CALCULATE BIAS....     6.00
RESET VALUE OF GAGE/RADAR BIAS ESTIMATE.....................     1.00
RESET VALUE OF ERROR VARIANCE OF BIAS ESTIMATE..............     0.50
MAXIMUM ALLOWED ERROR VARIANCE OF BIAS ESTIMATE.............     0.80
THRESHOLD TIME DIFFERENCE FOR ACCUMULATION GAGES............    15.00 MINUTES
TIME DURING WHICH BIAS IS DRIFTED BACK TO RESET VALUE.......    12.00 HOURS
SYSTEM NOISE................................................     0.05
VARIANCE ADJUSTMENT FACTOR..................................     0.50
# OF STANDARD DEVIATIONS FOR DISCARDING GAGE/RADAR PAIRS....     2.00
MAX GAGE ACCUMULATION ALLOWED...............................   400.00 MM
MIN HRLY GAGE OR RADAR ACCUM. NEEDED FOR BIAS CALCULATION...     0.60 MM
```

Figure 5-23. STP Alphanumeric Product (AWIPS Version 5.2.1 will change in AWIPS version 5.2.2)

User Selectable Precipitation

USP product legend description: (Fig. 5-24)

- RPG ID: kxxx
- PRODUCT NAME: User Def Total Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

USP product annotations:

- VCP: 11, 12, 21, 121, 31 or 32

Additional USP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, OHP/THP data levels or STP data levels used

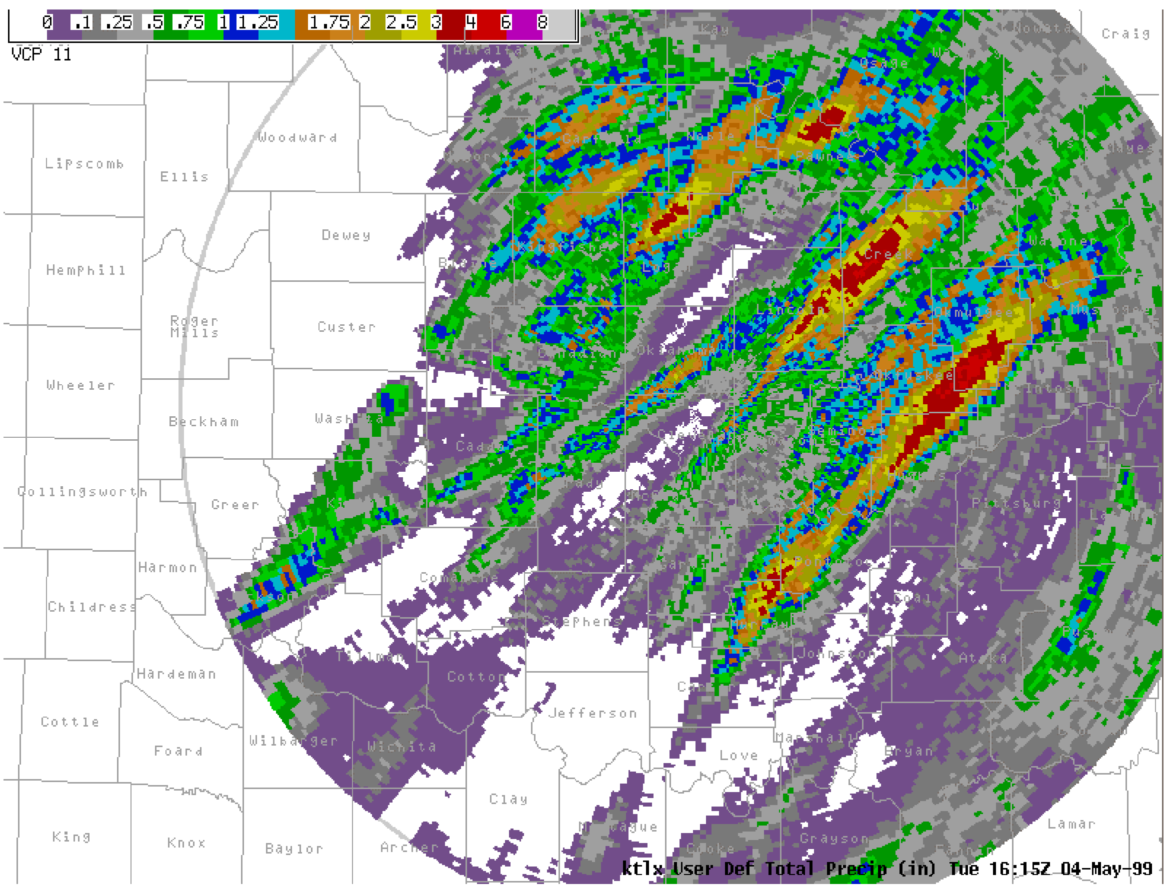


Figure 5-24. User Selectable Precipitation

dependent on the magnitude of accumulations Displays precipitation accumulations for a user specified period of time using top of the hour accumulations. The past 30 hours of top of the hour accumulations are available.

User selects duration (up to 24 hours) and end time

- Default USP generated for 24 hours ending at 12Z.

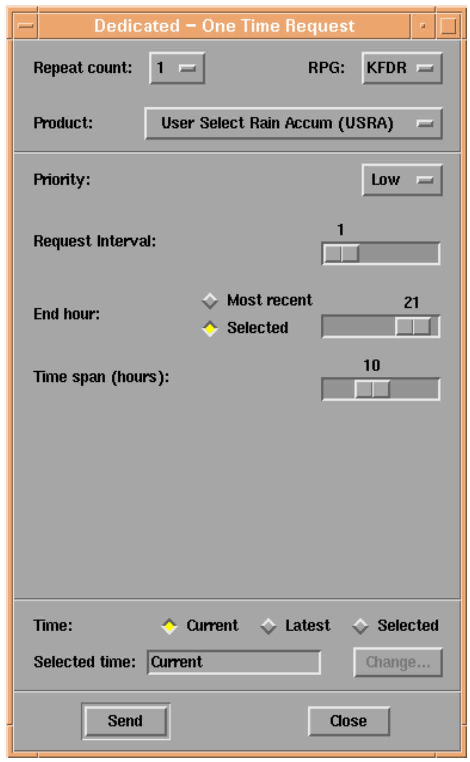


Figure 5-25. One Time Request

User Selectable Precipitation - Applications

1. Flexible time interval to meet varying weather situations
2. In addition to the 24 hour default USP, any others generated for dedicated users are available by OTR to dial-up users.

User Selectable Precipitation - Limitations

1. USP accumulations are updated only at the top of the hour

2. Product may contain missing data. At least two thirds of the specified hourly accumulations must be available for product generation.
3. Since the USP is a customized product, only 10 can be generated per volume scan.

One Hour Digital Precipitation Array (DPA)

The RPG produces another hourly product, called the One Hour Digital Precipitation Array (DPA). Instead of the 1.1 nm x 1° polar grid, the DPA has a rectangular grid of about 2.2 x 2.2 nm. Instead of 16 data levels, the DPA has 256 data levels. Similar to the One Hour Precipitation Product, the DPA has a moving one hour of accumulation (scan-to-scan accumulations). The product is used by the RFCs to generate precipitation input for the NWS River Forecast System (NWSRFS), and the AWIPS Multisensor Precipitation Estimator (MPE) used for the bias calculation. The rectangular grid allows for mosaicking the numerous WSR-88Ds within the RFC's area of responsibility.

Supplemental Precipitation Data (SPD)

The Supplemental Precipitation Data is an **alpha-numeric only** product received at the AWIPS workstation like any other product. (Fig. 5-26)

The SPD includes output on PPS algorithms (each volume scan) such as:

1. current bias value and whether it is applied,
2. information on gage-radar pairs,
3. information on the number of blockage bins,
4. percent of the hybrid scan bins filled, and
5. other output from the PPS.

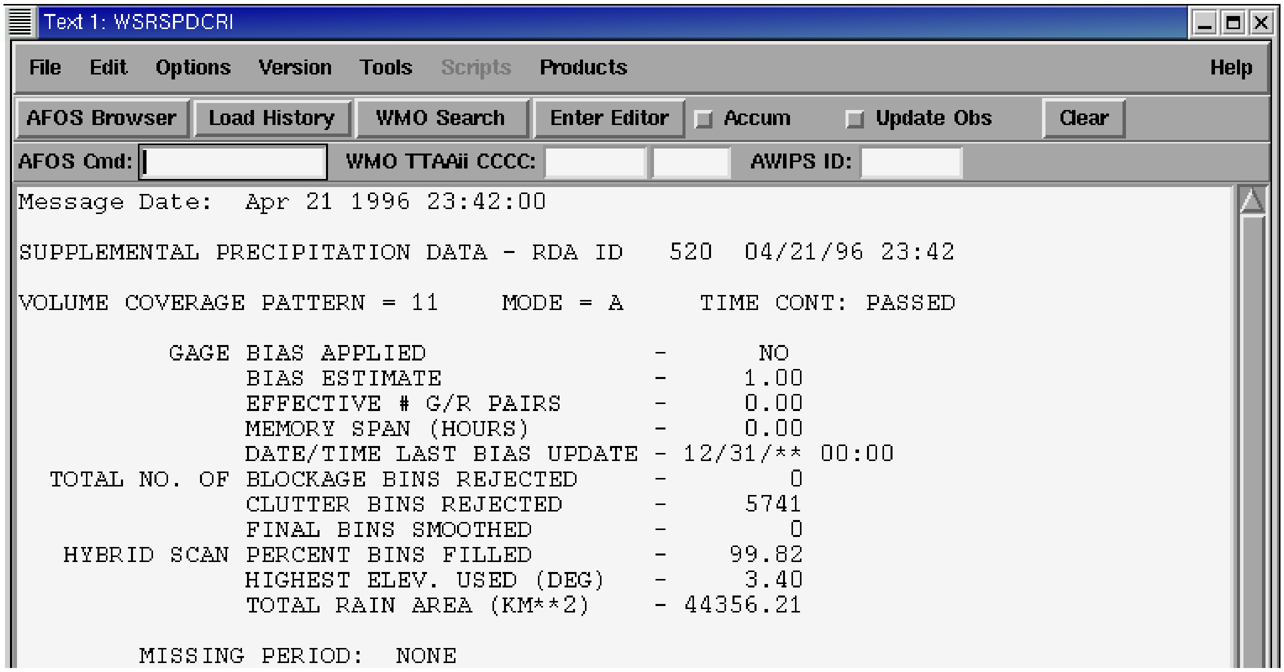


Figure 5-26. Supplemental Precipitation Data

Precipitation Data Levels

Introduction

Data levels on the One Hour, Three Hour, and Storm Total Precipitation products may be edited at the RPG HCI in accordance with policies set forth by your local Unit Radar Committee.

Why modify Precipitation Data Levels?

Data level changes depend on the location of the radar, topography and previous weather in the area of concern. For example, data levels in parts of the Western states may need more detail in the lower end of the scale than areas of the Gulf Coast states.

One/Three Hour Precipitation Products

The One/Three Hour Precipitation product has 16 accumulation data levels corresponding to each of the 16 color codes represented on the product.

The first data level is non-modifiable and has the acronym ND (No Data) for areas with no accumulation or areas outside the product coverage area.

The second data level is also non-modifiable and is given a value of > 0.00. This is color code 2 and displays regions with accumulations greater than zero but less than the level set for code 3.

The remaining levels, codes 3 to 16, are modifiable by the operator and range from 0.05 through 12.70 inches in multiples of 0.05 inch.

Storm Total Precipitation Product

The Storm Total Precipitation product also has 16 data levels and is modified the same as the One/Three Hour product. The only difference is the range of the data levels.

Once again levels 1 and 2 are non-modifiable. Levels 3 to 16 are modifiable and range from 0.1 through 25.4 inches in multiples of 0.1 inch.

Editing OHP/THP Data Levels at RPG HCI

Click on User - Products - Selectable Parameters - OHP/THP Data Levels (See Fig. 5-27.)

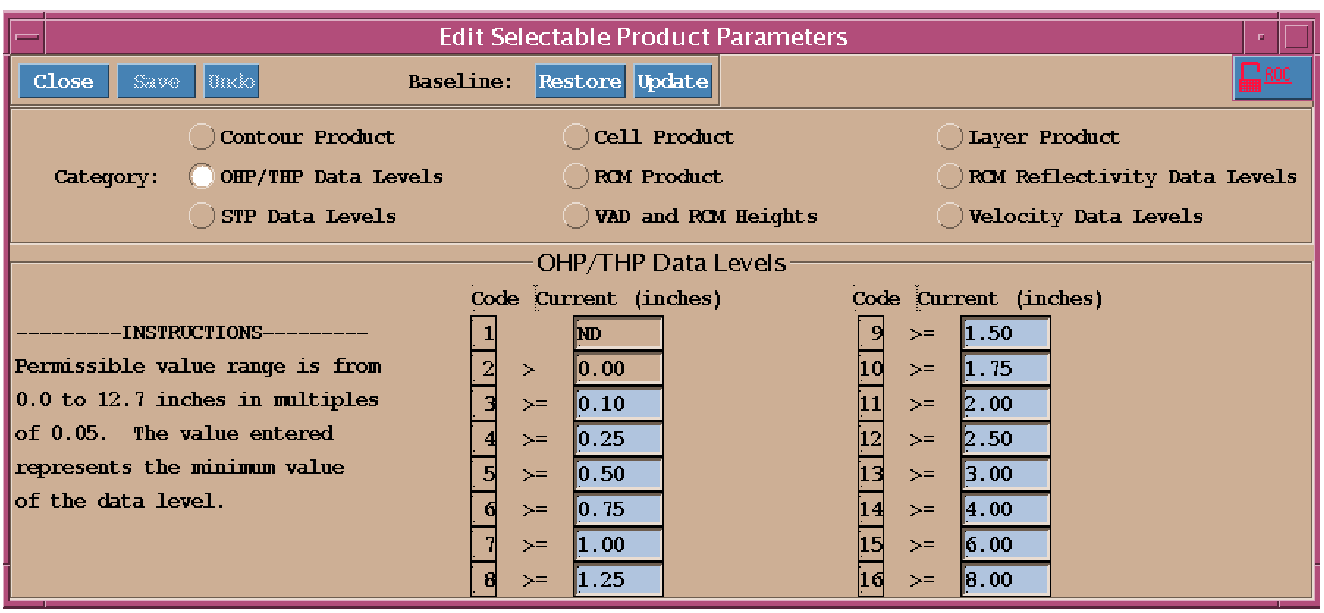


Figure 5-27. Edit screen for the OHP/THP product data levels at the RPG HCI.

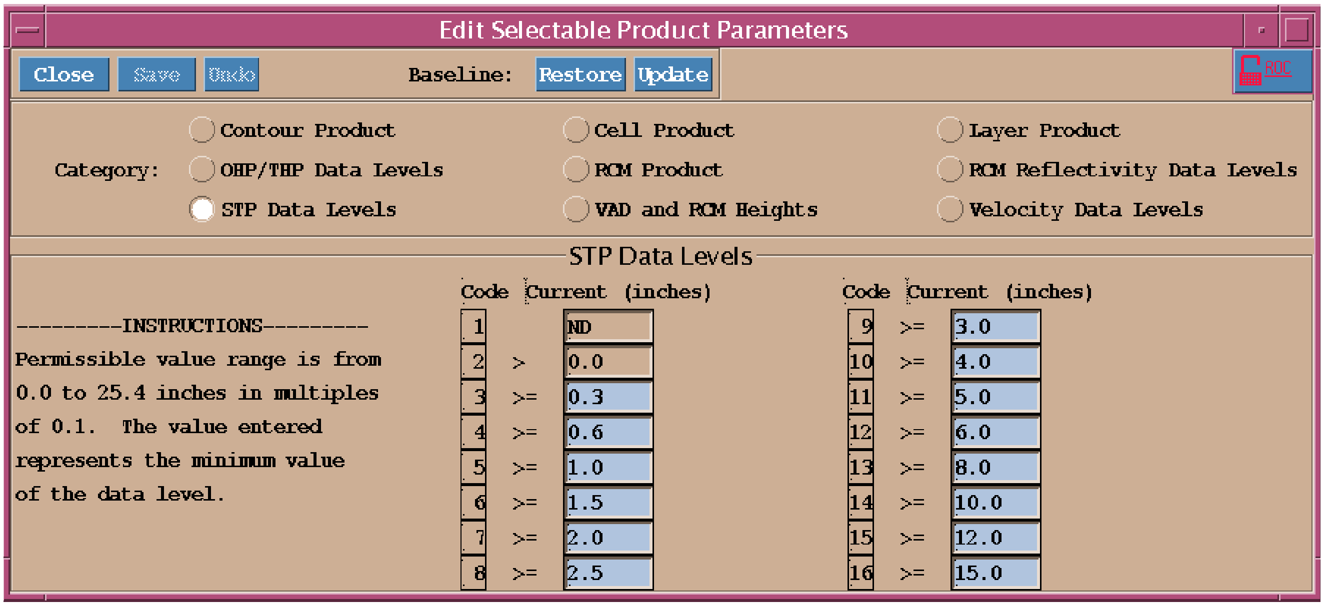


Figure 5-28. Edit screen for the Storm Total Precipitation product data levels on the RPG HCI.

Editing STP Data Levels at RPG HCI

Click on User - Products - Selectable Parameters STP Data Levels (See Fig. 5-28.).

Summary - Precipitation Products

Graphical and/or Alphanumeric Products at the AWIPS Workstation

1. Hybrid Scan Reflectivity (HSR)
2. Digital Hybrid Scan Reflectivity (DHR)
3. One Hour Precipitation (OHP)
4. Three Hour Precipitation (THP)
5. Storm Total Precipitation (STP)
6. User Selectable Precipitation (USP)
7. Digital Precipitation Array (DPA)
8. Supplemental Precipitation Data (SPD)